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PROCEEDINGS

1991 ACQUISITION RESEARCH SYMPOSIUM

VOLUME TWO

CO-HOSTED BY THE
DEFENSE SYSTEMS MANAGEMENT COLLEGE
AND THE
NATIONAL CONTRACT MANAGEMENT ASSOCIATION
WASHINGTON, DC CHAPTER

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91-10541

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1991 ACQUISITION RESEARCH SYMPOSIUM

Acquisition for the Future

Imagination, Innovation, and Implementation

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The 1991 **Acquisition Research Symposium** is the latest in a series of conferences begun in 1972. These Symposia offer a dynamic forum for dialogue among key professionals working on vital issues facing the acquisition community. Attendees include senior officials, program managers, staff officers, and researchers from the Department of Defense, federal civilian agencies, academia, and industry.

This year's theme reflects the future innovation and implementation in the acquisition process. "*Acquisition for the Future - Imagination, Innovation, and Implementation*" is the prevailing theme discussed and examined throughout this publication. The papers included cover the latest research and development as documented by individuals involved in the many aspects of the acquisition process.

We invite you to take advantage of this publication, which expands upon Symposium presentations and introduces new authors and topics. Please note that the views expressed are those of the authors and do not necessarily reflect the views of the organization with which they are associated.

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ABSTRACT

Reliability, Availability, Maintainability Enhancement of Communication-Electronic Systems (RAMECES)

Russell A. Vacante, Ph.D.
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In the spirit of Total Quality Management, and for the first time in the history of the Communication-Electronics Command, Ft. Monmouth an interdisciplinary task force has been assembled to proactively identify, evaluate and implement methodologies for improving the Reliability, Maintainability and Testability (RM&T) of Army Communications-Electronic Systems. The RAMECES task force, the name give to this endeavor, has been in existence since September 1988. During initial brainstorming sessions the task force targeted 99 RM&T areas to be investigated for improvement. The 99 areas of interest have been divided into the following three groups; improving RM&T without increasing Operation & Support (O&S) cost, the integration of software and hardware RM&T requirements, and customer satisfaction with fielded systems.

By focusing on lessons learned from key note speakers, representatives of government and industry the interdisciplinary RAMECES task force has developed both a philosophy and methodology to be applied to target programs. The approach adopted by the task force is to "design in" RM&T requirements during early stages of the acquisition life cycle. By taking an interdisciplinary team approach to problem solving, we have been able to improve contractual language by encouraging use of state-of-the-art technology.

One way we have chosen to improve contractual language is by modifying the Command's Solicitation Preparation Manual (SPM). The SPM has been altered to include a clause requiring contractor's bidding on Request for Proposals (RFP's) to use state-of-the art technology. The RAMECES task force has also developed a generic Full Scale Engineering (FSE) package for soliciting RFP's, Statement of Works (SOW's) and standardized guidance documentation that is presently being applied to a target program. From our discussion with key representatives from government and industry, the task force has sponsored a number of research projects. These projects include efforts in VHDL, VHSIC, and MIMIC technology, and the creation of testability requirements.

The RAMECES task force has recognized that software requirements are a driving force and account for the preponderance of monies being spent in the procurement of new equipment and systems. To reflect recent trend towards the integration of hardware and software acquisition, the RAMECES task force provided funds to the Product Assurance and Test Directorate's support contractor to: (1) develop a methodology which assures that reliability requirements are achievable with system software, and (2) to compile a software test methodology measuring and computing the reliability of software under operational conditions. Other software tasks are currently in progress. The task force has also succeeded in improving RM&T and reducing operational and support cost by sponsoring developmental and production efforts which encourage the implementation of state-of-the-art technology. Through efforts such as these the RAMECES task force has set the pace for the implementation of Total Quality Management (TQM) at CECOM and possibly throughout the U.S. Army.

Reliability, Availability, Maintainability Enhancement

of Communication-Electronic Systems (RAMECES)

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FORWARD

The RAMECES task force was created in September 1988 for the primary purpose of improving the way in which CECOM contracts for Reliability, Maintainability and Testability (RM&T). Although the task force finds its home at Fort Monmouth, many of the issues it addresses and the experience it gains has the attention and support of the AMC community.

During the Fall of 1988, Mr. Seymour J. Lober, Deputy Chief of Staff for Product Assurance, HQ AMC and Mr. Martin J. Burger, then acting director of Product Assurance and Test, discussed possible methods for improving the RM&T of Army equipment. Shortly thereafter the Product Assurance and Test Directorate developed the RAMECES concept. After approximately one year of activity CECOM's Commanding General, Billy M. Thomas, chartered the RAMECES task force on August 11. 1989.

Originally the task force consisted of two teams: the Hardware Tiger Team, established on September 29, 1988, and the Software Tiger Team established on October 25, 1989. In December 1989 the two teams were merged into the RAMECES task force in an effort to streamline the work effort and in recognition that hardware and software issues recently have become highly interdependent.

The thirty five member"interdisciplinary" task force which consists of members from both the research and development and readiness communities, has adopted Total Quality Management (TQM) as its working philosophy. The RAMECES task force is one of the earliest interdisciplinary, multi command process action teams in the U.S.Army assigned with the task of addressing RM&T issues at the earliest point and continuing through all phases of the life cycle.

INTRODUCTION

In the pages that follow, the discussion will focus upon the composition of the RAMECES task force, the management tools used by the task force to solve problems associated with contract clauses and RM&T requirements, and the approach the task force has taken with respect to contracting for the latter.

Also to be discussed are some of the methods used to address RAMECES tasks and some of the accomplishments of the task force to date. Measures that have been taken to enhance i.e., improve contract clauses and requirements, will be talked about in some detail as will be target programs which the RAMECES task force has selected for trying out recommended contractual revisions.

Obstacles that yet need to be over come by the task force in the near future will be part of the closing discussion of the paper so as to point to the future role of RAMECES at Ft. Monmouth and possibly throughout the U.S. Army itself. Within this discussion corrective actions for some of our persistent problems will also be recommended.

GENERAL APPROACH TO SOLVING PROBLEMS

The RAMECES task force has focused most of its time and energy on establishing realistic RM&T requirement of communication electronic systems and equipment early in the life cycle. To begin to accomplish this, it was necessary to ensure that the RAMECES Task Force be composed of representatives from both the readiness and the research and development communities at Fort Monmouth. The task force therefore, includes engineering, support, quality assurance, logistic, procurement and legal representation of the readiness side of the house and from the CECOM research and development centers.

Representation from the Laboratory Command (LABCOM), Electronic Technology & Device Laboratory and Avionics Research & Development Activity (AVRADA) research and development activities are also part of the RAMECES task force, thus providing us with abroad research and development base. This 35 member task force, which meets approximately six hours every two weeks, has adopted a TQM approach to problem solving and in doing so has held rank in abeyance so as to facilitate communication among task force members. This approach has helped the task force make improvements in contractual language that is meaningful to both the managers and technical personnel charged with tasks associated with RM&T contractual requirements.

The task force, using TQM management tools such as brainstorming, fish bone charts and Pareto Analysis, identifies the RM&T issues to be investigated, recommends when appropriate necessary corrective action and a plan of implementation. To date the RAMECES task force has identified 99 RM&T subjects that warrant some degree of investigation. Thirty three of these have had been addressed by members of the task force. The task and the status of accomplishments taken with respect to these 33 RM&T issues can be found in the five reports published thus far by the task force.

The tasks addressed to date, include RM&T contractual requirements from the Concept and Exploration to the Production phase of the acquisition cycle. Since the task force has adopted the approach that realistic RM&T requirements should be designed into communication electronic equipment, our time is increasingly devoted to improving contractual language tasks related to the preproduction life cycle phases. It is the task force's contention, contrary to one scholarly opinion, that our efforts will result in long term improvements in the reliability, maintainability and testability of CECOM items which, in turn, should result in budget decreases[1]. To overcome the objections of this author who suggests that contracting early for RM&T requirements might result in increased government spending, RAMECES has tied RM&T contractual requirements to pilot projects and historical data collected and evaluated prior to implementing innovative contractual language on a much larger scale. What follows is a discussion of some measures taken by the task force for improving contractual language for RM&T requirements. Included in this discussion are some projects funded by RAMECES and other related activities designed to ensure RM&T contractual requirements at CECOM.

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[1] J. Ronald Fox, The Defense Management Challenge, Weapon Acquisition (Harvard Business School Press, 1988), p.48

IMPROVED CONTRACTUAL LANGUAGE AND TARGET PROGRAMS

One of the earliest and least complex actions taken by the task force was the inclusion into the Solicitation Preparation Manual (SPM) of a clause which encourages the utilization of state of the art technology that has demonstrated some potential for improving the RM&T of CECOM items. This clause requests, "The offeror's (to) specifically address perceived opportunities for utilization of Very High Speed Integrated Circuitry (VHSIC) and other advanced technologies" and to perform a trade off analysis to each alternative according to performance, reliability and maintainability, supportability, schedule, and cost (labor & materiel) requirements. This clause is probably a contributing reason why VHSIC technology has increasingly been offered by CECOM contractors in response to Requests for Proposals (RFPs).

The RAMECES task force has developed and implemented or is in the process of implementing numerous Statement of Works (SOWs) that are designed to improve equipment and system RM&T by ensuring that such matters are implemented during the earlier phase of the life cycle. We have developed SOWs for thermal programs, reliability growth, step stress testing, failure analysis procedures for microelectronic devices, software reliability, incoming inspection and even an SOW for incentivizing reliability contractually.

In a related and parallel effort, the task force has developed generic requirements to be used during the engineering development phase of the life cycle to enhance contract language to ensure that RM&T requirements are "designed into" CECOM items. These requirements were specifically developed for the Full Scale Engineering Development (FSED) Phase of the Silent Fox program, a pilot project of the RAMECES task force. Currently, these requirements are being used by our technical personnel as a template for other FSED projects. These SOWs, that were originally written for the Silent Fox program, provide guidance to technical personnel pertaining to quality assurance and reliability programs, failure analysis reporting, reliability modeling, allocation and prediction criteria, maintainability predications, review programs, etc.

Maintenance Directorate inputs for the Silent Fox and other FSED programs include contractor guidance for logistical support analysis, provisioning, technical manuals, technical manual requirements, test requirement documentation and unit maintenance courses. Since these generic requirements are intended as guidance documents and not technical mandates for insertion into FSED Request for Proposals (RFPs), technical personnel are requested to tailor the use of these requirements on a case to case basis. The generic requirements, which have been inserted into the Reliability and Maintainability Acquisition Handbook developed by the former Product Assurance Directorate, Fort Monmouth does nevertheless, tell technical personnel how to effectively contract for reliability and maintainability.

In addition to the Silent Fox program the RAMECES task force has targeted other programs for the purpose of affecting RM&T requirements during the early phases of the life cycle. In these instances, consideration of improved technology at the earliest point in the acquisition process for improving the way CECOM contracts for RM&T has been the objective. Lessons learned from SINCGARS and MSE are being applied to programs such as the Modular Adaptive Signal Sorter, the Common Module ELINT Subsystem and the SINCGARS Data Rate Adapter. In conjunction with ET&DL LABCOM, the RAMECES task force has funded two new technologies that are currently part of the contractual requirements for the previously mentioned systems. The research effort with ET&DL LABCOM is bringing us very ... se to having Parts Obsolescence Requirements defined by VHSIC Hardware Description Language (VHDL). Contractual language which ensures that the functionality and structural design of these research and development efforts will be provided or has been provided to the appropriate project leaders. A second endeavor we have with ET&DL LABCOM has resulted in an SOW which demonstrates that Built In Test (BIT) can be implemented via integrated circuits into existing microwave (MW) and millimeter (MMW) circuity. This BIT technology can determine the real time functionality of the circuit/module/system under test.

The RAMECES task force has technologically supported and funded research into Army Fault Tolerant Architecture (AFTA). Working with the Avionics Research and Development Activity we have helped to sponsor a conceptual study that is designed to ensure the reliability, maintainability and testability (among other things) of AFTA technology for both air and ground vehicles. The SOW the RAMECES task force has provided to the contractor includes VHSIC Hardware Description Language (VHDL), reliability, maintainability, testability trade-off of thermal design and device technology (CMOS, NMOS, VHSIC) requirements. All of which will help ensure that the RM&T requirements of the AFTA program can be determined within specified confidence limits at the earliest stages of the life cycle. RAMECES provided seed money to the AFTA program that allowed a one year early start to that program. Also, RAMECES was directly responsible for developing a teaming effort between AVSCOM and CECOM development communities thereby saving significant Army resources that would have resulted from a duplication of tasks.

PROBLEMS ENCOUNTERED

At the time the RAMECES task force was established, top level managers from participating activities lent their full support and provided representation at the biweekly meetings in a consistent manner. With the reorganization of CECOM for streamlining purpose the priorities of the Command have shifted and a number of new mangers have taken on additional and different tasks and employees. The issue we must to address under these circumstances is how to prevent the interruption of our tasks, which has the potential of threatening RAMECES very existence. This is a potential threat whenever there is a command reorganization or when individual players change their job positions. The job of keeping the endeavors of this task focused is complicated in our environment of diminishing human and financial resources since participation in task force activities strains the resources of the participating activities. Currently, these issues are being worked by the Task Force Leadership. Efforts are under way to revisit all the directors in the command to identify problems areas and seek organizational support to achieve solutions to the resource issues. Also, within RAMECES Task Force individual "Stars" will continue to get letters of appreciation and money awards in support of their efforts. In the past "Two Star" Letters were written by the CG, CECOM in support of the program. We expect that these and other personnel and organizational motivation plans will continue to assure the success of RAMECES.

The method by which RAMECES funds projects is a persisted problem that needs to be addressed by the top level managers of the government. This problem persists due to the inherit nature of how monies within the government are allocated for specific missions. The so called"color" of money has inhibited the task force from taking corrective action on contractual matters for tasks tied to both readiness and research and development efforts. For example, monies provided from the readiness side of the house cannot be used to reimburse research and development efforts. The solution to this problem is to establish clearly defined research and development and readiness funding lines for which RAMECES tagged money can be applied. Source of this money currently is provided through such funding methods as taxing Project Managers, laboratories and readiness accounts established within CECOM. Once funding lines have been established the RAMECES mission to improve RM&T requirements by enhancing contract language will be achieved.

FUTURE GOALS

Establishing RM&T requirements early during the acquisition life cycle will continue to be a major thrust of the RAMECES task force. Currently, the task force is contemplating three approaches for developing RM&T requirements early-on. Soldiers and other users of CECOM equipment will be invited to task force meetings for the purpose of discussing problem they might have encountered operating CECOM equipment and items. Lessons learned from these discussions and demonstrations will be applied to future procurements. Next, users will be invited to work with designers during the research and development phase, for the purpose of determining whether or not designs created with the aid of Computer Aided Design (CAD) models meet their mission objectives and are "user friendly." The RAMECES task force is also in the process of establishing an RM&T data base so that a historical record of equipment performance on CECOM items is be maintained which in turn, will help us determine what RM&T requirements we should impose on procurements of the same or new technology. Ways of acquiring field reliability data etc., as input to this data base are also being investigated. Lastly, with the cooperation of private industry, the task force will devise a methodology for establishing a contractor database so that past contractor performance becomes part of the weighted factors for award. In the interim, the task force will incentivize RM&T requirements on target programs for the purpose of stimulating contractor interest and skill with regard to this matter.

In summary, the RAMECES task force has both short and long term goals for improving the reliability, maintainability and testability of CECOM items. The task force efforts at achieving this endeavor will largely depend upon continued management support and commitment in providing both human and financial resources in a dependable manner. As indicated by this brief discussion, RAMECES is taking a proactive as opposed to a reactive stance to "enhance contractual language" and thus improve RM&T requirements. We will continue to do the up-front planning and implementation necessary to ensure that RM&T requirement are designed-into electronic equipment and systems procured by CECOM. In working with both the users and contractors of CECOM items we will begin to establish a base line, as opposed to a quick fix, for improving the way RM&T requirements are contracted for at CECOM.

ADP HARDWARE

and

SOFTWARE

STREAMLINING THE SOFTWARE ACQUISITION PROCESS

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ABSTRACT

This paper discusses a universal approach to the acquisition management of large software systems. Results are derived from the Fort Monmouth, New Jersey, U.S. Army Communications-Electronics Command (CECOM)/Industry Documentation Task Force (DTF) and select CECOM Mission Critical Defense System (MCDS) acquisitions. The purpose of these results is to eliminate unnecessary documentation while allowing for improved visibility and control over the systems under acquisition.

INTRODUCTION

The purpose of new practices in acquisition management is to reduce cost while maintaining or improving the visibility and control during development, and providing the necessary support documentation. This paper examines approaches and practices that have accomplished these objectives in the category of Software MCDSs written in Ada programming language.

GENERAL

The CECOM/Industry DTF was initiated with SoftCon 89. A group of individuals from Industry and CECOM, Fort Monmouth met eight times over a one-year period. The result of these meetings was a report [1] that clarified problems and proposed solutions. Some of the proposed solutions have been implemented to various extents in the U.S. Army acquisition process. These solutions involved ongoing interaction of Software Specialists with Program Managers. Preliminary findings point to reduced documentation and cost while improving visibility and control over projects by Program Managers.

One example of the subject matter under study is given by Table 1, which is a work breakdown of one Computer Software Configuration Item (CSCI).

Table 1 summarizes the efforts to prepare the Software Design Document and Interface Design Document and to support their

TABLE 1. WORK BREAKDOWN OF ONE CSCI - 20K LOC

	PRELIMINARY DESIGN				
	DEVELOP PRELIMINARY DESIGN		9 MAN-MONTHS	43.0%	
160 PAGES	PREPARE PRELIMINARY SDD		4 MAN-MONTHS	19.0%	
160 PAGES	PREPARE PRELIMINARY IDD		4 MAN-MONTHS	19.0%	38% FOR 2167A DOC.
	SUPPORT CSCI PDR		3 MAN-MONTHS	14.0%	
	IDENTIFY AND SUPPORT CSC TEST REQUIREMENTS		1 MAN-MONTH	5.0%	
		TOTAL	21 MAN-MONTHS		
	DETAILED DESIGN				
	DEVELOP DETAILED DESIGN		17 MAN-MONTHS	42.5%	
240 PAGES	PREPARE SDD		6 MAN-MONTHS	15.0%	
200 PAGES	PREPARE IDD		5 MAN-MONTHS	12.5%	27.5% FOR 2167A DOC.
	SUPPORT CSCI CDR		4 MAN-MONTHS	10.0%	
	PERFORM PROTOTYPING ON RISK AREAS		4 MAN-MONTHS	10.0%	
	DEVELOP AND RECORD CSC AND CSU TESTS		4 MAN-MONTHS	10.0%	
		TOTAL	40 MAN-MONTHS		

NOTE: 1 PG/4 HRS
SDD 400 PAGES
IDD 360 PAGES

reviews. This represents 38 percent and 27.5 percent of the work for preliminary and detailed design activities, respectively.

Figure 1 depicts the software documentation cycle for systems development (see following pages for Figures 1, 3, 4, and 5). It becomes apparent that documentation is very costly, both in time and in capital.

RECOMMENDATION

The following solutions are proposed for addressing the problems outlined in the preceding General Section. Essentially, two key concepts are recommended:

1. Establishment and utilization of Software Review Teams (SRTs)

2. Adoption of a High-Level Software Design Document (HLSDD) and review.

Figure 2 depicts the informational capacity of the SRT that promotes visibility and control over the project.

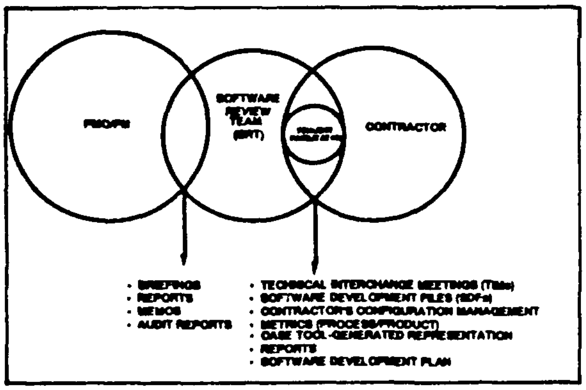

FIGURE 2. TRANSITION OF INFORMATION

Figure 3 proposes an alternative to the costly iterative nature of design and documentation as shown by Figure 1.

Figures 4 and 5 motivate the usage and adoption of an HLSDD.

The relationship of Preliminary Design Review (PDR) to the HLSDD is provided by Table 2, while the contents of the HLSDD are provided by Table 3.

TABLE 2. PRELIMINARY DESIGN REVIEW (PDR) AND HLSDD

• A single PDR held at total software system level-
  - Early in development process
  - High-Level Design

• HLSDD will be in plain-language, hardcopy format and will specify:
  - Hardware environment
  - Software architecture
  - Software Requirements Specification (SRS) traceability to software architecture
  - External interface definition
  - Man-Machine Interface

TABLE 3. HLSDD PRELIMINARY DESIGN INFORMATION

Overall Static Architecture

BFA UNIQUE	REUSE LIBRARY	COMMON APPLICATIONS		
CASS	REUSED SOFTWARE	GFE SOFTWARE		
O/S	Db	GRAPHICS PACKAGE	Ada/RTS	COMM SOFTWARE
DISK	PROCESSOR	GRAPHICS DISPLAY	COMM INTERFACE	

CONCLUSION

Supporting evidence for adoption of the proposed recommendations has arisen with multiple U.S. Army acquisitions. Meanwhile, certain pilot projects are using these approaches. It is the hope of the authors that unnecessary and overly costly documentation for acquisitions will be deleted from the Contract Delivery Requirements List items and that SRT members will capture necessary information in proactive and ad hoc fashions.

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[1] CECOM/Industry Documentation Task Force Report, Vol. 1, Vol. 2, 11 June 1990.

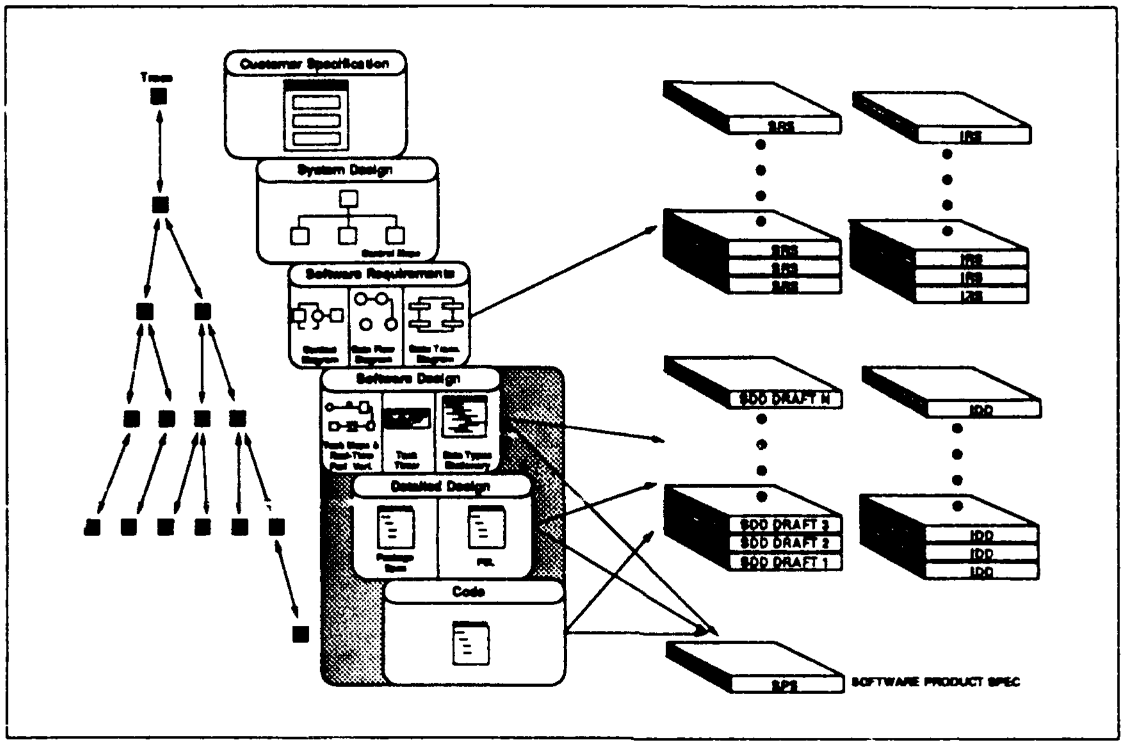

FIGURE 1. COSTLY ITERATIONS OF DOCUMENTATION

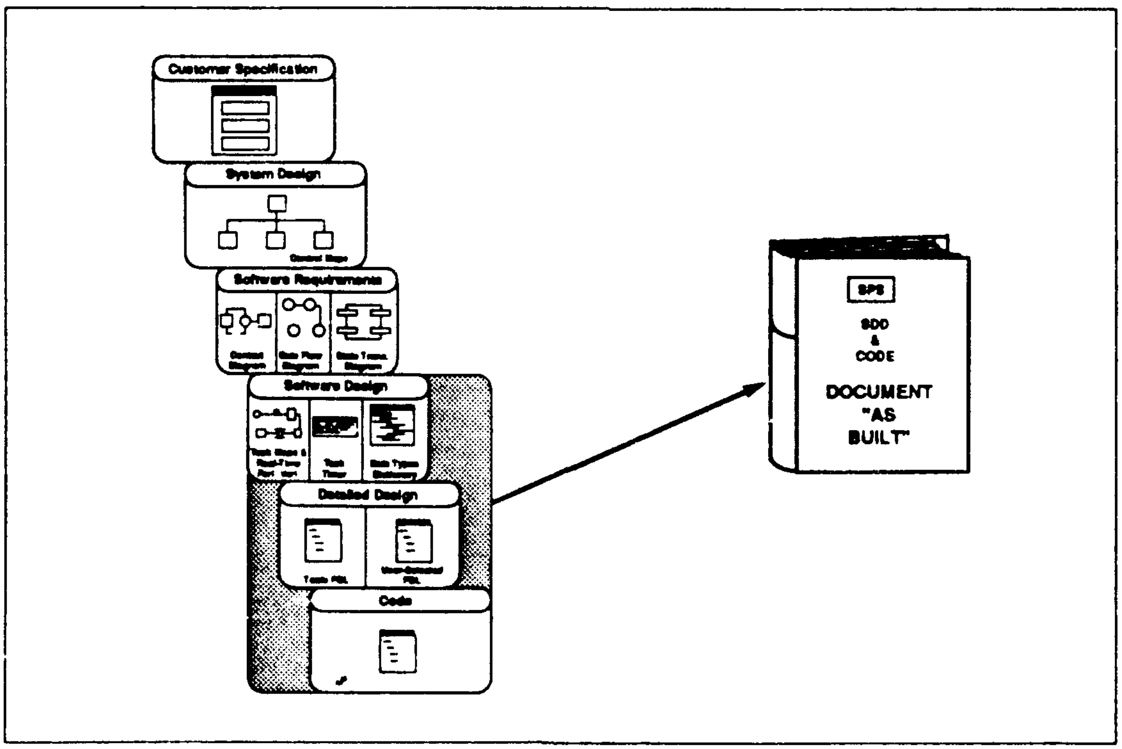

FIGURE 3. DOCUMENTING "ONE TIME ONLY"

FIGURE 4. FOREST OF DESIGN

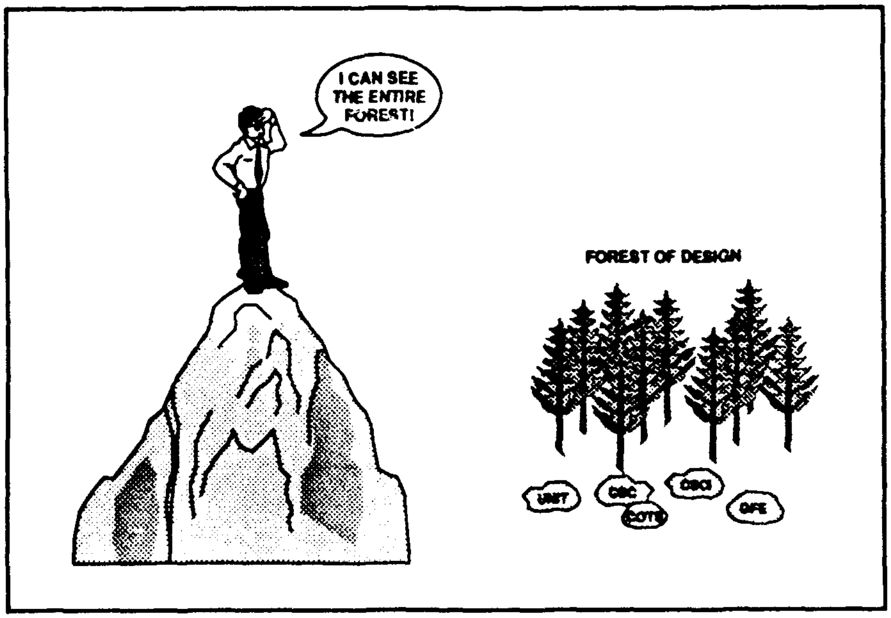

FIGURE 5. THE HIGH-LEVEL SOFTWARE DESIGN DOCUMENT

CONTRACTING IN THE SOFTWARE ENGINEERING CRISIS

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ABSTRACT

The Department of Defense (DoD) is currently experiencing extremely serious problems with Software Engineering. As weapons systems become increasingly more dependent upon the software programs which they employ, it becomes evermore apparent that DoD projects are consistently late and over budget because of software. To this end, software has become the dominant risk to cost and schedule and has caused the demise of more than a few DoD development projects.

The DoD repeatedly demonstrates requisite experience to efficiently manage the development of hardware. Hardware development projects, for which the DoD readily implements tried and proven practices to systematically address all aspects of the development, are relatively risk free at their onset.

Software development projects, on the other hand, are oftentimes initiated without the benefit of similarly institutionalized methodologies and practices. Because an understanding of proper Software Engineering practice is only now developing, standard, well-accepted measures do not yet exist. The DoD seems only to be scratching at the surface of state-of-the-art software engineering and herein lies the basis of the problem.

INTRODUCTION

Experience at the Naval Ocean Systems Center has demonstrated that Software Engineering plays an ever increasing, key role in our ability to be successful, responsive to sponsor requirements, and competitive. Recent innovations in the Software Engineering discipline promise to reduce risks associated with this type of development if we are able to effectively adopt and utilize them. The Naval Ocean Systems Center Technical Director has made a major commitment of Center resources by establishing the Software Engineering Process Office, and implementing plans to eventually reach higher levels of process maturity. Only through proactive measures such as this can we, as a Center, continue to meet our mission in this vital area. In fact, the Software Engineering Crisis threatens our reputation and thus, our continued work in Navy systems.

The approach adopted by the Technical Director only addresses part of the problem, perhaps a minor part of the problem. Most of the software developed at this Center is developed by support contractors. The average locally based support contractor is incapable, without substantial initial and sustained investment, and sharply increased skill levels, of performing the state-of-the-art Software Engineering needed to reduce the risks associated with software development projects. In order for the Naval Ocean Systems Center to be able to take advantage of these new Software Engineering Processes, our support contractors must be motivated to become partners with us by adopting the same philosophies and taking similar proactive measures to improve our Software Engineering capabilities. Neither can do it alone. As contractors improve their ability to meet our needs for quality software, our ability to serve the national interest will be improved by awarding contracts to those with the best capability. To provide this motivation, we must give our contractors an opportunity to compete with one another with regard to modern Software Engineering, and we therefore need the tools with which to measure Software Engineering competency. We have them.

CAPABILITY ASSESSMENT

The Software Engineering Institute (SEI) is a federally funded research and development center, formed in 1984 in response to the need for advances across all phases of the Software Engineering process. The SEI is a unit of Carnegie Mellon University, under contract with the DoD. Its mission, based upon an assumption that sound engineering processes lead to quality software, is to influence rapid improvement of the quality of operational software in mission-critical computer systems, to accelerate the reduction to practice of modern Software Engineering techniques and methods, to promulgate the use of modern techniques and methods throughout the mission-critical systems community, and to establish standards of excellence for Software Engineering practice.

ASSESSMENT TOOL

The SEI Technical Report "A Method for Assessing the Software Engineering Capability of Contractors" dated September 1987 provides us with a tool, as its title implies, with which to assess the Software Engineering Process Maturity of our contractors. We found that the SEI assessment instrument can be used to facilitate objective and consistent assessments of the ability of potential DoD contractors to develop software in accordance with modern Software Engineering methods. This assessment instrument is basically a questionnaire calling only for yes or no answers to questions based on the following premises:

- The quality of a software product stems, in large part, from the quality of the process used to create it.

- Software engineering is a process that can be managed, measured, and progressively improved.

- The quality of a software process is affected by the technology used to support it.

- The level of technology used in software engineering should be appropriate to the maturity of the process.

- Software products developed by contractors for DoD use are acquired under contracts invoking DOD-STD-2167A, Defense System Software Development, as tailored for each contract.

The SEI questionnaire is arranged so that the capability to perform software engineering is divided into three areas:

- Organization and resource management,

- Software engineering process and its management, and

- Tools and technology.

To provide a structure for assessment, five levels of process maturity and two stages of technology advancement have been postulated:

Process Maturity Levels:

1 - Initial: The initial environment has ill-defined procedures and controls. The organization does not consistently apply software engineering management to the process, nor does it use modern tools and technology. Level 1 organizations may have serious cost and schedule problems.

2 - Repeatable: At Level 2, the organization has generally learned to manage costs and schedules, and the process is now repeatable. The organization uses standard methods and practices for managing software development activities such as cost and estimating, scheduling, requirements changes, code changes, and status reviews.

3 - Defined: In Level 3, the process is well characterized and reasonably well understood. The organization defines its process in terms of software engineering standards and methods, and it has made a series of organizational and methodological improvements. These specifically include design and code reviews, training programs for programmers and review leaders, and increased organizational focus on software engineering. A major improvement in this phase is the establishment and staffing of a Software Engineering Process Group that focuses on the software engineering process and the adequacy with which it is implemented.

4 - Managed: In Level 4, the process is not only understood but it is quantified, measured, and reasonably well controlled. The organization typically bases its operating decisions on quantitative process data, and conducts extensive analyses of the data gathered during software engineering reviews and tests. Tools are used increasingly to control and manage the design process as well as to support data gathering and analysis. The organization is learning to project expected errors with reasonable accuracy.

5 - Optimized: At Level 5, organizations have not only achieved a high degree of control over their process, they have a major focus on improving and optimizing its operation. This includes more sophisticated analyses of the error and cost data gathered during the process as well as the introduction of comprehensive error cause analysis and prevention studies. The data on the process are used iteratively to improve the process and achieve optimum performance.

Software Technology Stages:

A - Inefficient: Multiple implementations may be avaialble and the practice may be in widespread use, but the technology is no longer effective. An organization that primarily employs inefficient software development technology is likely to be ineffective in developing software. Moreover, at this technology stage some important software engineering practices are not practical in large complex developments.

B - Basic: Multiple implementations are available, and they have been demonstrated to be effective. An organization that primarily employs basic software development technologies is likely to be moderately effective and, depending upon the maturity of its process, reasonably consistent in its performance.

SEI Guidance

The SEI offers guidance for assessing the capability of contractors, using the assessment instrument. Such assessments may be conducted either in the pre-solicitation qualification process, in the formal source selection process, or both. This Software Capability Evaluation (SCE) method should be used to augment the many steps currently involved in source selection. However, the effectiveness of a SCE is critically dependent on the process used in the assessment and on the background and training of the personnel conducting it. Information contained in the document itself providesthe SEI guidance for its use:

- When used as part of the formal DoD systems acquisition process, the questions are furnished, for information purposes, to potential bidders with the Request for Proposal (RFP).

- Answers to the assessment questions are not submitted with the proposal, but are provided to an assessment team that visits each competing contractor during the proposal evaluation period.

- Several days of classroom instruction must be afforded each of the competing contractors, to review the assessment questionnaire in detail and discuss the materials and support tools that should be available to demonstrate performance for each question.

- The Government assessment team will visit each competing contractor during the evaluation period. Several major software development projects, as agreed to by the contractor and the assessment team, will be assessed. A period of 3 to 4 days is needed to review the questions, obtain and discuss back-up material, demonstrate support tools, and present conclusions. A single assessment team should be used to visit all of the competing firms to assure consistent interpretation of both the questions and the results.

- The assessment team must have a mix of talents. A minimum of four experienced professionals are required, including those knowledgeable in the software development process, the technology, the application area, and the specific procurement. All team members must have been trained in the SEI SCE process. This training is available in a 3-day course of instruction offered by the SEI at Carnegie Mellon University.

- At the conclusion of each assessment, the contractor's management is informed of the findings and given an opportunity to offer evidence to refute any disputed findings and to explain their plans for process improvement.

- The results of each assessment are made available to the Source Selection officials for consideration prior to contract award.

Following the SEI guidance, as above, will provide a thorough assessment of the software engineering capabilities and process maturity of all competing contractors. However, the following points should be considered:

- Costs involved with the above implementation could soar. Training and on-site assessment for a single contractor may be well in excess of $20,000, depending upon location, i.e., local contractor, or one which is located somewhere between San Diego and the East Coast. Furthermore, there is an average of seven respondents to every solicitation issued by the Naval Ocean Systems Center.

- The above implementation process could lead to contract award to an unqualified firm if none of the competing contractors are at the software process maturity level required to support the requirements of the contract.

EMERGENT NEED

In the light of the current Communications Department and Contracts policy to move away from the large, omnibus type contracts to smaller and more project specific contracts, we in the Operational Systems Branch, Code 833, of the Submarine Communications Division were faced with an emergent need for contract support for several of our projects. We determined that the contract support needed covered a broad range of disciplines, but that the predominant need was for efficient software engineering which would enable significant risk reduction in current and future development projects. More specifically, our need was determined to be contractor support which could immediately respond with software engineering capability commensurate with SEI Level 2, or higher process maturity. We decided to invoke the SEI Software Capability Evaluation (SCE) method in a solicitation and source selection process.

OUR APPROACH

Since the scope of the support contract would cover a wide range of disciplines, We were concerned that a single contractor, capable of modern software engineering practices, may not have the necessary background and experience needed to adequately support the remaining requirements. For this reason, we prepared a synopsis for publication in the Commerce Business Daily (CBD) which encouraged contractor teaming.

Because of the considerations above, i.e., high cost and the possibility of gaining unqualified contractor support, the SEI assessment methodology had to be tailored. Therefore, we developed a Source Selection Plan which provided the necessary tailoring to the SEI guidance for using the assessment document, and clearly stated the additional requirements to be incorporated into the solicitation:

- A prerequisite that any respondent to the RFP demonstrate that they are currently performing software engineering practices at the SEI Level 2, or higher process maturity, was established.

- To determine the level of software process maturity, the SEI assessment document was included with the RFP; each offeror was required to perform a "self-assessment". Results of the self-assessment were submitted with the proposal; however, this was not used in conjunction with the technical evaluation for scoring purposes.

- Technical and cost proposals were evaluated to determine the relative ranking of all offers with respect to the "greatest value to the Government". However, prior to contract award, the Government did perform an on-site validation of the contractor's SEI self-assessment. The validation was performed by a qualified, SEI trained team of professionals. The RFP stated that in the event that a contractor in line for award, technical and cost considered, failed to demonstrate a current SEI Level 2 or higher process maturity, the next offeror in line for award would undergo this on-site validation, and so forth until the otherwise qualified contractor, meeting the prerequisite SEI level of process maturity was determined.

To strengthen the technical proposals, and to ensure that the selected contractor would continue to perform at the leading edge of software engineering, we required each competing contractor to submit a "Software Standards and Procedures Plan" as a part of their proposal. In the RFP, we specified the criteria to be presented in the plan. This criteria consisted simply of those individual elements commensurate with SEI Level 2 process maturity. In order to ensure compliance, this plan was heavily weighted within the overall technical evaluation. And finally, we required that this plan become binding upon the contractor for all software work to be performed under the contract.

The importance of the technical proposals was established in the source selection process by setting a relatively high technical to cost ratio in the source selection plan. Our approach to contractor source selection for work on "Airborne Submarine Communications" projects was successful in gaining the level of engineering competence needed. By design, our approach led to contract award only to a qualified, SEI Level 2 or higher firm. It did; however, exclude from competition, any firm which may be presently SEI Level 1 albeit very close to SEI Level 2 performance. We found our approach to be highly cost effective since we needed to conduct only one on-site validation of the SEI self-assessment. Our approach readily demonstrated our intention, as evidenced by the unusual number of contractor questions, cries of unfairness, and one formal protest, to insure that the contract award be competed primarily on technical issues. After all, the SEI Level 2 process maturity has not previously been a prerequisite to contract award. Our approach to contractor selection provided the following experiences:

- We received four proposals to our solicitation, each representing contractor teaming arrangements with a single prime contractor.

- One offer was eliminated initially, based on a very weak technical proposal. This left three offers in the technically competitive range.

- Evaluation of three Best and Final Offers reinforced the original ranking; however, eliminated one offeror from the technically competitive range.

- The contractor in line for award, based on the "Greatest Value to the Government" as determined by technical and cost evaluations, was also determined to be currently operating at the prerequisite level of software process maturity.

- There was one formal protest which was withdrawn following technical debriefings and clarification of the Government selection process.

CONCLUSION

In conclusion, the SEI guidance for using their Technical Report, "A Method for Assessing the Software Engineering Capability of Contractors", dated September 1987, can be extremely time consuming, prohibitively expensive, and could lead to contract award to an unqualified firm. The Naval Ocean Systems Center's approach to implementing this assessment instrument in the solicitation and source selection process offers expediency, provides cost control over the process, and excludes all potentially unqualified offerors. However, the risk of contractor protest should be considered under the latter approach.

STRATEGIES FOR THE INTEGRATION OF DIVERSE SOFTWARE SYSTEMS

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ABSTRACT

The advent of micro-computers has led to the explosive growth in the number of software applications. These applications can substantially improve productivity in an acquisition office environment. However, each system follows a different implementation strategy. The result of these differences is a steep learning curve for users in offices where a number of different software tools are employed.

The software industry has begun to recognize this difficulty and has responded with a variety of software integration products. This paper identifies a number of the approaches to this problem and presents a discussion of the two predominant strategies which have emerged for integrating office software and leveling learning curves: Integrated Software Packages (ISPs) and Integrated Software Interfaces (ISIs). The benefits and drawbacks of each are discussed, and a synthesis of the two strategies is proposed. Finally, a case study of an ISI-ISP synthesis is presented.

INTRODUCTION

The rapid growth of micro-computer (PC) automated data processing (ADP) technology during the 1980s has affected every facet of American society. Computers have promised to enhance productivity in the work-place and in the classroom by making mundane, repetitive tasks faster and easier. Data which used to take years of research to acquire is now made readily available in minutes from automated data base management systems (DBMSs). Information which once had to be collected by individual researchers is now a commodity bought and sold by large supply houses. Once collected, this information can be manipulated and modeled through sophisticated application programs. All of this capability afforded by the digital computer is designed toward a common goal: greater individual and collective productivity.

Because PC technology is still in relative infancy, there is a proliferation of incongruous system strategies. Hardware designs differ dramatically from vendor to vendor in order to accommodate not only the hardware system's intended purpose but also the manufacturer's business strategy. As in any new market niche, an overabundance of companies has appeared in the ADP market to offer a mind-boggling collection of data management solutions, each with its own design paradigm and implementation. This accumulation of hardware and software tools has resulted in general user confusion. Because each system tends to employ unique user interfaces and command structures, an ADP user's learning curve can be steep. The demands of time and effort which the modern ADP environment makes on the user can become so great that users will often avoid using automated data management tools altogether.

Compounding this problem is the fact that the computer revolution has, in large part, left behind senior managers and experts in non-ADP fields, many of whom were already installed in top positions before computers entered the work place. These individuals have never enjoyed the computer education of their younger subordinates. This "education gap" has resulted in a general aversion to computer automation in offices where critical strategic and research decisions are made. From a purely financial point of view, it is too expensive to train these people in a broad variety of ADP solutions. Hence, senior personnel, acquisition or otherwise, often operate in an environment devoid of some of the most powerful efficiency-enhancing tools currently available.

With all the confusion in the computer marketplace, new software must be developed to bridge the gap between each user's area of expertise and the capabilities of the digital computer. Steps in this direction have already been taken in the DBMS arena. Over the last several years, DBMS vendors have moved toward the adoption of the IBM[1] Structured Query Language (SQL) standard as the "data management language of the future". In addition, many DBMS products can now be employed on a variety of operating system platforms. Several vendors also include "Query By Example" tools with their products. While these changes in DBMS technology have been very helpful to the programmer community, most of these systems are still too diverse for users who may need to access several different DBMSs operating on a broad assortment of platforms. While DBMS vendors continue to compete to dominate their own segment of a competitive market, the development of truly universal, flexible solutions seem unlikely.

Despite the major advances in data base and other software packages, serious challenges still exist for the worker who has not had a solid education in the use of computers. Every commonly used software package enforces its own usage rules, as well. For example, simply because an individual is fluent in the Microsoft Word[2] word processor, does not mean that the individual will find the transition to another software package like WordPerfect 5.0[3] an easy one. The whole strategy for implementing a document on each of these systems is different from each other. Other popular software systems, such as spread sheets suffer from similar implementation specificity problems.

Clearly, the learning curve associated with the digital revolution has serious consequences for the acquisition community. Although ADP offers great hope to enhance the quality of management in the procurement process, the expense involved in the training of personnel can require compromises which threaten to offset the potential benefits of automation.

What is needed, then, is a comprehensive, intelligent interface which can serve to mediate between the user and the data and services he requires. Such a system would require a standard, simple interface, which would be easily learned by researchers without substantial ADP experience. In addition, the software would have to seamlessly bridge a variety of software applications, accommodating many of the office workers different requirements. Ideally, from one interface, the user could conveniently access relevant data, and then manipulate that data for modeling purposes or for inclusion in documents.

TWO APPROACHES TO THE PROBLEM

Unity among software vendors regarding the integration or interchangeability of software tools has been slow in coming, but some attempts have been made. From the wide variety of computer standards, two major strategies for serving this requirement have arisen:

INTEGRATED SOFTWARE PACKAGES (ISPs)

The first and most common approach has been for a single software vendor to provide software which includes a variety of tools for daily office management. One of the best known of these systems is Lotus Development's Symphony[4]. This package includes a spreadsheet, word-processor, data base, and telecommunications manager through a consistent screen and keyboard access method. Other systems incorporating similar features include Enable Software's "Enable"[5], Ashton-Tate's "Framework"[6], Microsoft Inc.'s "Works"[7], and MDBS's "Knowledgeman"[8]. Each of these systems may be "programmed" through the use of procedural scripts (generally known as macros) further enhancing the integration of the various facets of the system. In addition, these systems permit the user to integrate textual material, data, spreadsheet results, and graphics into unified documents, and to communicate this information electronically to other local or remote offices. In general, each integrated system provides many of the functions of non-integrated software packages at a smaller expense. In most cases, it is far less costly to buy one integrated software package than to purchase individual packages to obtain all the capabilities of integrated software. Figure 1 depicts a basic ISP.

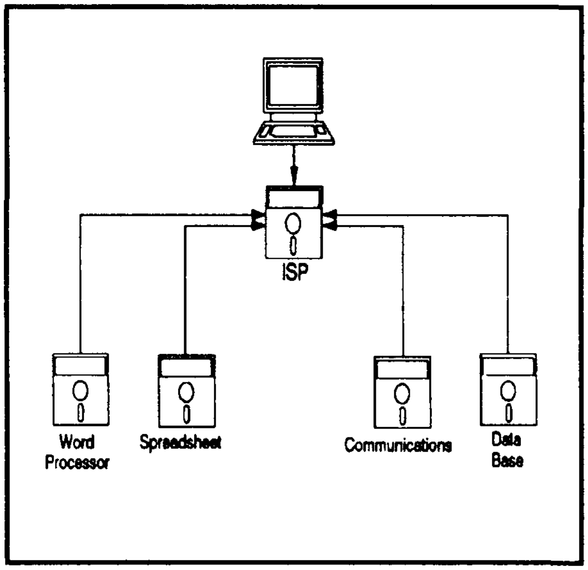

Figure 1 - Integrated Software Packages

A number of acquisition offices have successfully employed these systems to achieve greater automation with a minimum of training expense. An excellent example of this approach to ADP integration is The Paperless Procurement System[9], which uses "Knowledgeman" integrated software to provide users with automated procurement forms, as well as other general office automation tools. The system, which has been tested at a variety of government offices, allows its users access to a complete suite of tools, while requiring the user to understand a single simplified interface. Much of the system is menu-driven, reducing the need for the user to understand Knowledgeman's natural language syntax. The system includes the added benefit of being conveniently portable across a variety of hardware/operating system platforms. This portability enhances the long term utility of the system, as acquisition offices grow and new hardware systems are required.

INTEGRATED SOFTWARE INTERFACES (ISIs)

The second approach to ADP tool integration has, until recently, received less attention than the integrated software package. Rather than attempting to provide a multitude of office automation functions, the integrated software interface provides a common interface between individual software packages provided by independent vendors. Figure 2 illustrates an ISI based system. The most prominent example in the DOS environment of this sort of interface is Microsoft Windows[10]. Much has been made of Windows' Graphical User Interface (GUI) and its new multi-tasking capabilities[11]. However, Windows' potential for integrating data from a broad variety of software packages stands out as one of its most powerful features. Windows permits the user to load several different applications simultaneously into different logical windows, which may be re-positioned on each user's PC monitor. While each application may not actually be operating simultaneously, the user may alternately access each application using a mouse pointing device. To permit data exchange between applications, Windows incorporates an important "Clipboard" capability, which allows the user to copy data directly from an application operating in one window to a completely different software application operating in another window.

The benefits of ISIs are many. One of the strongest and most commonly cited arguments in favor of this approach over an integrated software package is that each tool (eg. a spreadsheet) accessed through an integrated interface is optimized to accommodate its own purposes, without regard for other tools with which it might need to co-exist. Conversely, the integrated software package must incorporate compromises to accommodate the memory management and consistency requirements of each tool in the set. By employing an ISI and avoiding the compromises inherent in ISPs, offices are free to upgrade individual software tools as the state of the art in each tool's arena advances. This flexibility is not available in the office bound to a particular integrated software package, where users must often await the introduction of integrated package upgrades before benefiting from the latest software advances.

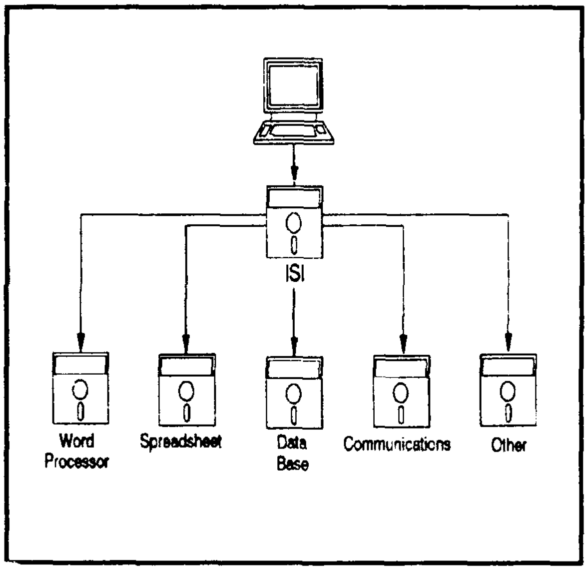

Figure 2 - Integrated Software Interfaces

Another, often overlooked advantage of the Integrated Software Interface is primarily political. In situations where ISPs are introduced into offices where the use of disparate software systems is the norm, there is often strong resistance to the new package. Each office in an organization has its own requirements and will often exert a great deal of energy learning and optimizing the tools which they employ on a day to day basis. When higher organizational authority dictates the use of an ISP with the intent of enhancing efficiency within the organization, much, if not all, of the prior optimization effort must be discarded and undertaken again. It is understandable, then, why the introduction of ISPs into a previously automated office frequently meets with resistance and sometimes fails altogether. ISIs, on the other hand, face far less resistance.

The modifications of office procedures in order to accommodate an ISI are far less demanding, and are effectively limited to the learning curve associated with the new interface. There is no requirement in this situation for employees to abandon software tools in which they have invested a great deal of time and energy.

ISI - ISP SYNTHESIS

Having outlined a number of the benefits of ISIs, *it is important to note that they are not* without their flaws. ISIs do not supply one of the primary benefits of ISPs: a common method of access to all tools used by an office. Returning to the Windows example offers an excellent illustration of this. While the Windows environment offers some important guidelines for memory and interface management, software developers are still able to implement their applications in unique ways. Users must therefore refer to users manuals and help screens to use Windows applications, just as they would for other more conventional applications. Hence, despite the potential that ISIs hold for integrating data, they still do not reduce the learning curve found in offices where a broad variety of software is used by various personnel. Merely giving the user the ability to interchange data between applications, does not necessarily mean that the user will understand how to properly use all the applications between which he may need to interchange data.

One instance of this problem is found in the realm of DBMSs. Various DBMS systems offer *substantially different interfaces and* query syntaxes and follow different paradigms. For example, the popular dBASE[12] data management language employs a record-oriented data management approach within files, whereas distributed SQL or Entity-Relationship data base "engines" process complex queries for the user and return the data in sets. In addition, each DBMS, regardless of the standard to which adheres, includes unique capabilities and quirks, which appear as a result of each vendors attempt to optimize their own software. In the case that a user wanted to query an ORACLE[13] or INFORMIX[14] SQL data base server he might type: "SELECT <Field> FROM <Table>". However, if the same user desired additional data from a ZIM[15] Entity-Relationship data base, he would be required to type: "FIND ALL <Table> USING <Field>". A truly integrated interface would have to accommodate all of these approaches, as well as others, in a unified and simplified fashion.

There is an obvious need for full-spectrum data integration, from data source to modeling tool. As the discussion of ISIs and ISPs shows, this need is as yet unfulfilled. In essence, a synthesis of the two approaches to ADP integration is required: one which offers the flexibility and optimum capability of an ISI while providing the consistency and moderate learning curve of an ISP. Such a hybrid would have to be flexible enough to act as a common application interface while still accommodating virtually any application. Clearly this is not an easy task. In fact, for certain applications it might not be appropriate. For example, the idea of having a standard interface substitute for those found in individual word processors leaves a good deal to be desired. However, in the case of many DBMS products which may be queried directly without the use of vendor specific interfaces, this idea could bear fruit.

Imagine an office in which there was a need for a researcher to query multiple data bases on disparate platforms, integrate that data, and manipulate that data using a variety of modeling tools. In the current state of ADP evolution, the user would have to be fluent in each data base queried, understand the data formats which each data base returned, and understand how to convert these data formats into structures which the modeling tools could then use. This example requires an extremely experienced user, if not an expert programmer. The example also presents a problem which is very common in a number of office environments.

ISI - ISP CASE STUDY

The Budget Stability Data Management System (BSDMS) developed for the Research Directorate of Defense Systems Management College (DSMC/DRI-R) responds to a case very similar to the hypothetical example, above. Much of the work performed by the DSMC researchers involves studying major trends in Department of Defense (DoD) spending on several levels, utilizing top-line budget and program level spending information, as well as DSMC derived data. However, the researchers at DSMC have several, mostly independent, projects. As a result, a variety of software systems, such as Lotus 123[16], Lotus Symphony, and dBase III +, are used to store and analyze these data, thus making their transfer and compilation rather difficult and time consuming. Should one of the researchers need to use data obtained and stored by one of the other research personnel, data would have to be transferred via floppy diskette and translated into an appropriate form in order to be used by the researcher's software of choice. The BSDMS development effort arose from the need to integrate these diverse data bases and provide the DSMC personnel with the ability to more readily combine and analyze the existing data in novel and meaningful ways and to easily incorporate the data into graphics and written documents used by researchers to present their analyses.

As a first step in the system's development, an extensive functional analysis was undertaken in an effort to determine the best allocation of system requirements between hardware, software, and user. As a result of this analysis, it was determined that the BSDMS should provide DSMC researchers with: 1) a single, integrated repository for the variety of budget-related data collected and maintained by DSMC personnel; 2) a method to select, combine, and extract desired pieces of data for more detailed analysis using third party software, such as Lotus 123; 3) the ability to create and access additional dBase III+ compatible user-defined data bases without having to exit the system; 4) a standardized reporting capability; and 5) seamless interfaces with other third party software.

As a result of this functional analysis, a decision was made to use the Clipper[17] programming language. This decision was based on several considerations including the speed with which Clipper programs run and the dBase compatible structure of the data files, which allowed direct access to the data bases from dBase III +. The majority of the data bases in use by DSMC personnel were of the dBase variety. Therefore, the decision was made to convert the other existing data bases to a dBase format for

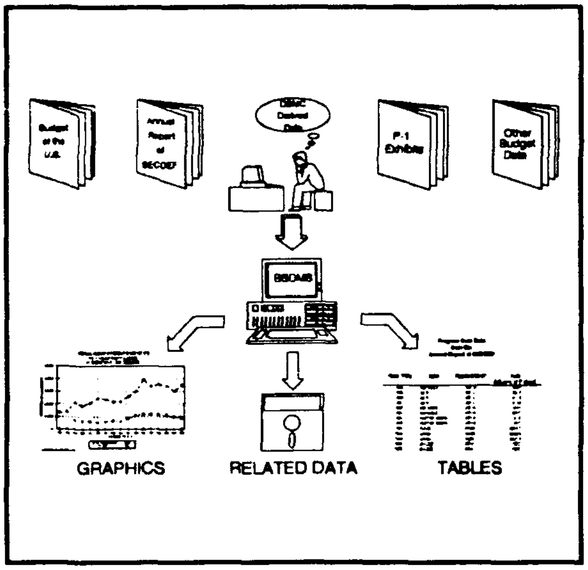

Figure 3 - BSDMS

integration.

The capabilities of the completed BSDMS provide the DSMC researchers with a powerful tool for data collection, storage, distribution, and analysis as illustrated in Figure 3. Of particular importance to the goal of complete data integration is the Data Transfer Utility of BSDMS. The Data Transfer Utility allows the user to select specific data elements from a variety of BSDMS data bases and combine and relate them to data elements from other system data bases. The user is able to select a particular data base of interest, select individual data fields from within the data base, select another particular data base, select additional fields, and so on. Once the selection process is complete, the user may identify key and related fields on which to sort this data. The user may further restrict the type and amount of information to be extracted by defining additional filters through which the data is processed. The flexibility of the data consolidation is further enhanced by allowing the user to design the layout of the resulting data file by positioning data fields prior to the extraction of the data to either a dBase compatible file or an ASCII text file. The resulting data base or text file will contain all the available information specified by the user for further analysis by third party software.

Another capability indicative of the flexibility of BSDMS is the Data Base Creation Utility, which allows the user to define additional data tables without having to exit BSDMS. Once defined, the user may add, edit, and delete data through BSDMS, or, if an existing data base or text file matches all or part of the newly created data base structure, may populate the user-defined data base from the existing data base or text file. These user-defined data bases are also accessible from the Data Transfer Utility allowing for the incorporation of the information contained within these data bases with data from other existing data bases.

A series of standardized reports is also available to the DSMC researchers. In addition to tabular print-outs of the data base contents, program and unit cost reports are also available in the form of both screen and hard copy graphic output. The user is able to specify the data source from which to draw the data, the weapon system name, and the base year to which all associated dollar values will be converted.

BSDMS is able to seamlessly interface with other third party software. Software packages such as Lotus 123 and WordPerfect may be called without having to exit the system. In addition, the fact that information from both the BSDMS and user-defined data bases may be exported in ASCII format allows for easy incorporation of this data into Lotus spreadsheets for analysis, WordPerfect for document production, or graphics packages such as Harvard Graphics and Lotus Freelance.

The success of BSDMS is due in large part to the numerous human factors considerations incorporated into its development. No computer language knowledge is required of the user. The system is completely menu and prompt driven. Its user-friendly interface is illustrated by a consistent color scheme throughout the system as well as a consistent arrangement of available user options. An extensive on-line help system is also available to the user with a simple F1 key press from anywhere within the system. General screen level help is available from all menu and data entry screens describing the options available to the user from the screen(s) in question. More detailed field-specific help is available during data entry and editing procedures. This help includes data definitions and the source(s) where the appropriate data for the specific field may be found. An F1 key press from several of the data fields produces scrollable lists from which the user may select appropriate data for filling the field.

In sum, while not achieving all of the goals of an integrated ISI-ISP system, the BSDMS does attain a much higher degree of data base integration than is ordinarily possible in many research or procurement offices. It allows the user to combine and extract data from multiple data bases, via a uniform user interface, for additional analysis using third party software with which BSDMS seamlessly interfaces. Extensive pre-development research and on-going consultation with DSMC personnel are some of the key reasons behind its success. Prototyping permitted ARIST to further refine the design of BSDMS to best suit the DSMC researchers' needs. The end result of this R&D, the Budget Stability Data Management System, serves as a powerful and flexible data management and analysis tool.

CONCLUSIONS

Integrated System Interfaces offer great promise for the enhancement of the automated office. The first attempts at this technology, however, offer only partial solutions. The ISI-ISP synthesis achieved by the DSMC/DRI-R BSDMS represents only a few features of complete software integration. While the system achieves many of the benefits of an ISI, it does not tackle the critical problem of integrating data stored in completely different data base management systems. This integration represents the next, and perhaps most important step in ISI development. Once true DBMS integration is achieved, the DBMS learning curve will be substantially reduced, and more of the goals of contemporary ADP will be realized.

ENDNOTES

1/ IBM is a registered trademark of International Business Machines, Inc.

2/ Microsoft Word is a registered trademark of Microsoft Corporation.

3/ WordPerfect 5.0 is a registered trademark of WordPerfect Corporation.

4/ Symphony is a registered trademark of Lotus Development Corporation.

5/ Enable is a registered trademark of Enable Corporation.

6/ Framework is a registered trademark of Ashton-Tate Inc.

7/ Microsoft Works is a registered trademark of Microsoft Corporation.

8/ Knowledgeman is a registered trademark of MDBS, Inc.

9/ Webb, David A., "The Paperless Procurement System", Proceedings Of The 1989 Acquisition Research Symposium.

10/ Windows is a registered trademark of Microsoft Corporation.

11/ Windows version 3.0 allows true multi-tasking (simultaneous operation of different applications) on Intel 80386 computers.

12/ dBase is a registered trademark of Ashton-Tate Inc.

13/ ORACLE is registered trademark of ORACLE Corporation.

14/ INFORMIX is a registered trademark of Informix Software Inc.

15/ ZIM is a registered trademark of Zanthe Systems Division of Sterling Software, Incorporated.

16/ Lotus 123 is a registered trademark of Lotus Development Corporation.

17/ Clipper is a registered trademark of Nantucket Corporation.

AN EVALUATION OF COST/SCHEDULE PERFORMANCE ANALYSIS SOFTWARE

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Captain Terry V. Smith, Air Force Institute of Technology

ABSTRACT

Although the popularity and diversity of cost/schedule analysis software is growing, an objective evaluation of the software has not been reported. From a survey of Department of Defense users, four software packages and weighted evaluation criteria were identified. The packages were then evaluated using *Expert Choice*, a multiple criteria decision support system based on Saaty's Analytic Hierarchy Process. In this paper, the purpose and results of the evaluation are reported. Saaty's Analytic Hierarchy Process is also briefly described.

INTRODUCTION

The use of personal computers and software to analyze cost and schedule performance data reported by defense contractors is increasing. For example, the recently revised Air Force System Command *Guide to Analysis of Contractor Cost Data* (AFSCP 173-4, 1 Sep 89) includes a new chapter that briefly describes seven automated analysis programs used by various organizations within the Air Force. The referenced chapter is purely descriptive. It is neither comprehensive nor evaluative.

There is a need to objectively evaluate existing cost and schedule analysis software. An analyst or organization contemplating adopting this software will likely not have the resources to thoroughly evaluate the alternatives. Also, the proliferation of different analysis software may result in confusion between analysts and organizations. Although the objectives may be the same, the use of different terminology and algorithms can be dysfunctional. Given this lack of standardization, errors may go undetected with the ability to explain differences in certain key indicators, such as Estimate at Completion, seriously impaired.

In this study, four noncommercial software packages were evaluated using criteria identified and weighted by users from Air Force Systems Command Product Divisions. A popular multiple criteria decision support tool, *Expert Choice*, was used to evaluate and rank the packages [2]. The evaluation was restricted to noncommercial software used on personal computers because this appears to be the trend in most government offices.

This evaluation is neither comprehensive nor an endorsement of any particular software. A responsible analyst should determine software requirements by carefully considering the specific **decision context**. As a minimum, this would include an identification of the decision makers and their decision problems. For example, being sensitive to the background and experience of the decision makers and the potential political impact of their decisions is essential in identifying the appropriate analysis and information requirements. For more on this point, see Christensen [1].

METHODOLOGY

Identifying the software and evaluation criteria. Based on a literature review and a survey of Department of Defense users, the following four noncommercial packages were identified for evaluation: *Performance Analyzer* (Space System Division); *CPR-EZ* (Air Force Cost Center); *Contractor Cost Analysis System* (Air Force Cost Center); *Contract Appraisal System* (Defense Systems Management College). Other noncommercial software were identified, but were not available for various reasons. See AFSCP 173-4 for a brief description of these packages.

To identify and weight evaluation criteria for cost and schedule analysis software, personnel in the Product Divisions of Air Force Systems Command who were familiar with performance report analysis were surveyed using two questionnaires [4]. From the first questionnaire, twenty-one criteria were identified. These are listed in Table I. In a second questionnaire, the same user group ranked the twenty-one criteria in order of importance. To facilitate the use of these evaluation criteria in *Expert Choice*, the listing was reduced to the fourteen criteria with the highest rankings and then organized into seven categories. The fourteen criteria, weights and categories are listed in Table II.

***Expert Choice* and the Analytic Hierarchy Process.** *Expert Choice* is an interactive program that can be run on personal computers. It is based on a multiple criteria decision methodology, termed the "Analytic Hierarchy Process," developed by Thomas Saaty [3]. By using this decision support software, users are able to consider both quantitative and qualitative criteria to evaluate and rank alternatives. Several books and numerous papers have described the theory and application of the methodology. Government agencies, consulting firms, and corporations have used the methodology to analyze complex decision problems. Zahedi [5] has reviewed this literature.

Saaty's Analytic Hierarchy Process (AHP) requires the user to decompose the decision problem into a hierarchy with at least three levels. The top level of the hierarchy specifies the overall objective or goal, the second level consists of evaluation criteria to be considered relative to that goal, and the bottom level consists of alternative solutions to the decision problem. In this study, the goal was to identify the best cost/schedule performance analysis software, the second level contained the seven evaluation criteria/categories, and the bottom level consisted of the four software packages to be evaluated.

Once the hierarchy is established, AHP requires the user to prioritize the evaluation criteria by making pairwise comparisons between the criteria. A matrix of the pairwise comparisons is generated using a ratio scale between 1 and 9 to translate verbal judgments into numerical values. *Expert Choice* helps the user to establish this matrix by a series of interactive questions that systematically makes pairwise comparisons between criteria. In this study, the weights provided by the respondents were used to answer the questions and establish the priorities. The relative importance (weights) of the seven criteria/categories are listed in Table III and are normalized such that the weights add to unity.

Table III also shows "inconsistency ratios" for each criterion/category. In the process of making pairwise comparisons between criteria or alternatives, inconsistent judgments are possible. For example, if A is preferred to B, and B is preferred to C, then A should logically be preferred to C. Otherwise, the A to C comparison is inconsistent because it violates the transitivity property of utility theory. In AHP the degree of inconsistency between the comparisons is measured by a "inconsistency ratio."

TABLE I

Desirable Characteristics of Cost/Schedule Analysis Software

(a)	Online help indexes.
(b)	Not specific to one type of computer.
(c)	A tutorial with various case scenarios.
(d)	Menu driven screens that are user-friendly.
(e)	Easy to install.
(f)	Easy to learn.
(g)	Output to printer and plotter.
(h)	Prints graphics and data.
(i)	Regression analysis capability.
(j)	Variance analysis capability with explanations.
(k)	Verifies input data accuracy.
(l)	Narrative section capable of summarizing data, explaining variances, and suggesting areas to investigate.
(m)	Well-written, easy to understand documentation.
(n)	Allows user to change formulas and update charts.
(o)	Help menus that are context sensitive.
(p)	Can read floppy disks from contractors.
(q)	Can be run on a personal computer.
(r)	Can receive contractor data electronically and interact with contractor's management information system.
(s)	Multiple EAC formulas with suggestions regarding which one is most appropriate.
(t)	Clear, concise output reports.
(u)	Flexible/adaptable to level of user.

TABLE II

Weighted Evaluation Criteria Used in Software Evaluation

Criteria	Weight	Category
(d) User friendly, menu-driven screens	21.00	Friendly
(j) Variance analysis	19.33	Tools
(i) Regression analysis	19.33	Tools
(e) Installation	18.33	Friendly
(f) Easy to learn	15.67	Friendly
(s) Multiple EAC formulas	15.33	Tools
(g) Output to printer and plotter	13.33	Mod/Print
(h) Prints graphics and data	13.00	Mod/Print
(n) Change formulas and update charts	12.33	Mod/Print
(q) PC compatible	12.33	PC
(r) Interact with contractor MIS	11.33	Interact
(l) Narrative section	11.00	Tools
(m) Good documentation	9.33	Document
(a) Online help indexes	8.67	Help

TABLE III

Criteria/Category Weights Developed From Expert Choice [1]

Criteria/Category[2]	Weight	Inconsistency Ratio
Friendly	0.205	0.061
Tools	0.183	0.037
Mod/Print	0.143	0.022
PC	0.139	0.000
Interact	0.128	0.036
Document	0.105	0.097
Help	0.097	0.087

[1] Expert Choice is a decision support tool based on Saaty's Analytic Hierarchy Process.

[2] These seven criteria/categories were used to evaluate the four cost/schedule analysis software packages.

TABLE IV

Ratings by Criterion/Category and Overall Ratings of Software

Criterion/Category	Cost/Schedule Analysis Software			
	PA	CAPPS	CCAS	CPR-EZ
Friendly	0.583	0.290	0.085	0.042
Tools	0.535	0.335	0.087	0.042
Mod/Print	0.246	0.175	0.289	0.289
PC	0.250	0.250	0.250	0.250
Interact	0.491	0.119	0.336	0.054
Document	0.674	0.168	0.117	0.040
Help	0.289	0.579	0.040	0.093
Overall rating	0.449	0.270	0.169	0.113

Based on experiments performed by Saaty, minor violations of the transitivity property are expected and quite acceptable as long as the inconsistency ratio is less than 10 percent. *Expert Choice* computes a inconsistency ratio for each comparison matrix. If the ratio is larger than 10 percent, the user is asked to redo the comparisons. Each time a pairwise evaluation is re-accomplished, a new inconsistency ratio is computed. Accordingly, the process of revising a pairwise judgment can help the user discover illogical thinking and generate insight into the decision problem.

The next step in the AHP is to make comparisons between alternatives for each criterion/category. As before, *Expert Choice* helps the user systematically make each pairwise comparison through a series of interactive questions. In this study, the comparisons between alternatives were made by an individual who was familiar with the four software packages.

RESULTS

Table IV shows the ratings for the four alternatives by each criterion/category. The overall ratings of the alternatives are shown at the bottom of the table. As can be seen, the software package judged the best was Performance Analyzer (PA) with a score nearly twice as large as Contract Appraisal System (CAPPS), an alternative package with the next largest score. Further analysis demonstrated that the superior rating was not particularly sensitive to changes in the relative weights of the criteria/categories. As illustrated in Table IV, Performance Analyzer was judged superior to the other packages for all but one category. For the HELP category, CAPPS had the superior rating. (The HELP criterion requires that the software be capable of tutoring the user on cost and schedule analysis.) This criterion received a weight of 0.289 from *Expert Choice*. For CAPPS to receive a score superior to Performance Analyzer, the weight on the HELP category would have to nearly double.

CONCLUSION

Although Performance Analyzer was the clear winner, the reader is cautioned again that software is best judged in its decision context. It is hoped, however, that this systematic and objective evaluation of four well-known cost and schedule performance analysis packages may benefit potential users contemplating adopting such software. In addition, the use of *Expert Choice* and Saaty's Analytic Hierarchy Process is recommended. We found this decision support tool easy to learn and quite useful for this multiple criteria decision problem.

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PROGRESS, PITFALLS, AND PROMISES: CURRENT ISSUES IN DEFENSE DEPARTMENT ACQUISITION OF COMMERCIAL SOFTWARE

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ABSTRACT

This paper briefly surveys current issues in DoD acquisition of commercial software. In the 1980's commercial software edged towards a greater role in defense systems, strenuously urged on by a host of defense procurement commentators and study commissions. A review of the cost structure of commercial software development, perhaps not generally understood outside the software industry, reveals the sources of its products' tremendous and widely-recognized cost and performance advantages.

These advantages notwithstanding, greater DoD acquisition of commercial software is now haunted and hobbled by procurement complexity, delay, and legal ambiguity. These unwelcome companions are the consequences of procurement practices oriented towards the product development, rather than towards sophisticated reliance upon existing commercial products.

The paper highlights some practical techniques for keeping these ghosts at bay, through better communication between and within both vendors and acquiring agencies. But fully banishing the ghosts will require more thoroughgoing changes: granting procurement personnel greater discretion to exercise their good judgment, and removing DFAR confusion about what exactly the DoD can do with commercial software, once acquired.

1.0 INTRODUCTION

Unanimity is a rare thing. Unanimity in areas as complex and amorphous as Federal procurement policy is rarer still. But unanimity about at least one fundamental procurement policy exists, and has existed for many years. Simply stated, there appears to be no theoretical or practical disagreement with the idea that the federal government in general and the Department of Defense in particular would be better served by greater reliance on commercially developed, commercially available technology; and, concomitantly, less reliance upon technology developed specifically for governmental applications.(2) The products may be variously described--commercial; COTS, standing for commercial-off-the-shelf; non-developmental items--but the idea is the same. They are products developed at private expense and sold in the commercial marketplace, products which coincidentally have useful defense applications.(3)

For many reasons, the unanimously endorsed policy goal of greater military use of commercial products has been honored in breach, rather than in practice, especially in the acquisition of technology. One survey claims even to detect "a slide away from commercial products and buying practices."(4) But there is at least one practical, if partial, commercial product procurement success story. That story is of the continually increasing use of commercial computer software by the DoD.

Success is relative, and perhaps this success can be understood only with reference to the dismal situation that prevailed in defense procurement of commercial software as late as the mid-1980's. Pioneering analysis under the aegis of the Software Engineering Institute at Carnegie-Mellon University systematically identified dozens of legal and methodological difficulties in such procurements, from the perspective of both the DoD and software vendors.(5) The Department and vendors subsequently became far more sensitive to these issues, and worked hard to circumvent them within the creaky framework of the existing procurement superstructure. Everyone did and is doing a good job, within those uncomfortable confines.

DoD acquisition of commercial software now certainly works, after a fashion: needs are assessed, costs are estimated, specs are developed, time frames are calculated, or guessed at. These ingredients are forced into the meat grinder of statutes, regulations, formal and informal acquisition practices, and vendor interaction. Out comes, eventually, the delivery of software that more or less meets at least some of the originally-identified needs. Whether, of course, the needs originally identified are those that actually exist at the time the software is delivered is another and a vexing problem.

While most observers would agree this grinder works better than in the past, no one would claim it works as well as it could. Certain aspects of the acquisition process have improved, but much greater improvement is needed, if commercial software is to more closely reach its cost-benefit potential in defense applications.

This paper focuses on these areas of potential improvement in three sections. It begins with a brief overview of the commercial software industry and two aspects of its underlying economics which clearly propel the policy mandate of greater defense use of its products. The second section discusses roadblocks to such greater usage. The final section discusses several approaches to removing these roadblocks--approaches of varying difficulty in implementation and varying likely degrees of efficacy.

2.0 DOING THE DoD'S (SOFTWARE) BUSINESS AND DOING (SOFTWARE) BUSINESS WITH THE DoD

There seems to be little doubt that the federal government is the country's largest consumer of software.(6) Exact or even widely-accepted numbers are maddeningly hard to pin down. In 1990 Defense Department spending on mission-critical software alone may have totalled $30 billion dollars.(7) Alas, there appear to be no consistently-cited reliable estimates of how much the DoD spends on commercial software as contrasted with the amount it spends on software developed to military specifications. Good reasons in addition to national security concerns explain the absence of such data: all such estimates must account for complex, confusing, and controversial distinctions between applications software and operating-system software, between pieces of custom-designed software and custom-designed software systems, among many others. These distinctions are, mercifully, beyond the scope of this paper. Simply summarized, no one disputes that the Defense Department buys a great deal of commercial software, and that these purchases have increased considerably over the 1980's.

Equally difficult to precisely capture is the size of the commercial software industry itself, again in part because of terminological confusion and also because lines between software, hardware, and consulting can be quite blurred within both vendor organizations and vendor financial reporting. But three facts are instructive. The November 1990 update of one popular source of software industry information(8) identifies approximately 1700 separate commercial software product vendors, some offering dozens of products, some offering only one.

As would be expected in an industry with so many participants, most are of very modest size. A May 1990 study of the 50 largest software firms reveals that the fiftieth-largest one had sales barely exceeding $30 million annually.(9) Interestingly, only 8 of the 50 were more than 20 years old.(10) The software industry is, therefore, well-populated, but most of its members are small, young firms.

Without doubt these 1700 firms will sell more and more of their products to the DoD whether or not improvements are made in the commercial software acquisition process. Less clear is whether defense software needs will be met efficiently and whether the DoD will be a marketplace for the most sophisticated, most reliable and overall most cost-effective technology. What drives the current defense reliance on commercial information technology? What compels every analyst of current practices to urge even greater such reliance? The considerations lying behind both can be illustrated intuitively with a simple hypothetical.

You have decided to design a new home for yourself. You work with your architect to draw up plans and specifications and you select a contractor, perhaps after a bidding process. Building begins, is completed, and with some luck, you survive and live happily ever after.

You've designed your home, but you are unlikely to even consider designing any of the major components that will make it up. Will you design a unique shaped and colored brick for the exterior, or design the bathroom fixtures, or the furnace? Probably not. Think for a moment even about the bricks. You'd need to develop (or hire) expertise about clays, about firing, about bricklaying, and so on. You'd need to get bids from brickmakers, evaluate the bidders, and oversee the brickmaking process. Wholly apart from the considerable costs, you are unlikely to be certain of your evaluation of your own needs, certain of your evaluations of bidding brickmakers, or comfortable with the time the process is likely to consume. You will therefore likely build your home, however unique, from bricks available on the market, relying on competition, warranties and other protections of the legal system, and your bargaining ability, to get the best brick value.

This model--building unique systems out of commercial components--is as much at home in the information-technology industry as it is in building construction. Increasing reliance on this model for software-related projects is the constant drumbeat of high-profile procurement reviews, even to the extent of suggesting the introduction of commercial products into systems previously designed wholly around customized components.(11)

The general economies and performance advantages of working with commercial products are intuitively obvious and supported by procurement policy directives over time. Less obvious, perhaps are the sources and magnitude of these advantages in the commercial software context. The underlying economics of the commercial software industry and its business climate drive the cost and performance advantages of its products in defense applications.

2.1 COST: A CHOICE BETWEEN GETTING WHAT YOU PAY FOR, AND GETTING MORE THAN YOU PAY FOR

Some software vendors, especially those offering primarily microcomputer software, refer to themselves as software *publishers.* This term is apt, for in economists' jargon both software vendors and, for example, magazine publishers, face low marginal costs in adding customers. Looked at practically, a large chunk of the costs of producing a magazine are incurred before the first copy is printed: paying photographers, writers and typesetters, management and so on. Comparatively, the actual additional costs of printing one more copy of the magazine--paper and staples--are quite modest. The big costs come before that.

True also for software vendors. The big costs of product design, development, quality assurance, users' guides, and so on are paid before the first copy of any software products goes out the door. The extra costs of creating one more copy of the product--a diskette or a roll of tape, printing another copy of the manual, and so on--are comparatively small. Looking from another perspective, a software vendor's ability, through good sales and marketing, to spread initial development costs across dozens, hundreds or thousands of users dramatically reduces the cost to each such user, compared to the costs each would incur if it independently developed the product for itself.

How much more does it cost to custom-develop? No generally-accepted rules of thumb exist, but the costs are likely to be exponentially greater, and outside of government the "custom" alternative is generally perceived to be *absolutely* the last resort.(12)

2.2 PERFORMANCE: MONKEYS, SPECS, AND THE MARKETPLACE

Of perhaps even greater importance than cost, especially in mission critical applications, is performance, encompassing suitability for current and future tasks, reliability, and so on.(13) There are two fundamentally different models software users can follow in attempting to assure themselves of good software performance. The models differ in who bears the burden of assuring performance, the burden we will call the performance monkey.

One model, the *specification* model, consists of attempting to "design in" performance. Analogous to the travails of a prospective homeowner attempting to design bricks, it will involve developing a great deal of knowledge about the precise needs to which the software will be put, the software development process, the hardware upon which the software will be installed, future hardware and communication trends, and myriads of other factors. This model relies upon specifications, standards, and similar devices to assure reliability. It is time-consuming and expensive, but worse, it squarely plants the performance monkey on the back of whoever develops the design. The specification model is unavoidable if the needs for which software is being sought are truly unique, but again, at least in private sector applications, it is avoided at all costs if that is not the case.(14)

The alternative model, the *marketplace* model, involves reliance upon commercial software vendors to assure reliability. Rather than focusing on a certainly difficult and perhaps futile attempt to fully understand the details of an organization's technical needs, this model focuses on surveying the marketplace for already existing software products, and on prospective vendors' track records with similar organizations. Relevant questions about vendors include whether they deliver on promises, technical and other; whether they keep products current, to reflect changes in hardware and changes in user needs; and so forth. Performance in the marketplace is seen as better assurance of reliability than is attempting to create this reliability through the imposition of detailed contractual roadmaps, on the theory that products and vendors which do not perform reliably, which do not represent good values, which do not meet buyers' expectations, have been and are being winnowed out of the industry.

Naturally, users' goals and needs must be articulated, and made part of the agreement. But they are expressed in functional terms--describing what the product needs to do, and the operating conditions under which it must do it.(15) No attempt is made to specify the details of how the product is to be designed, or tested, or documented. In the marketplace model, the monkey of performance is firmly attached to the vendors' backs.

Good sense requires that most software procurements, however humble or sophisticated, rely upon some amalgamation of the specification and marketplace models, giving the software's user and its vendor joint custody of the performance monkey. But for the DoD that is well-nigh impossible, given the realities of the current software procurement environment. The DoD acquisition process is overwhelmingly biased towards the specification model of assuring performance. That orientation, reflected in regulation, organization, and practice, is the root of virtually all remaining impediments to greater DoD use of commercial software.

3.0 THE TUNNEL AT THE END OF THE LIGHT: CURRENT ISSUES IN COMMERCIAL SOFTWARE PROCUREMENT

As noted in the introduction, most knowledgeable observers would agree that DoD acquisition of commercial software works better now than it has in the past. Trends are encouraging from both vendor and agency perspectives: e.g., the DFARS contain a mechanism for the incorporation of commercial software license agreements;(16) as the software industry matures, DoD procurement personnel encounter fewer vendors wholly unfamiliar with the intrinsic complexities of the governmental marketplace.

But everyone seems also to agree that major moves towards greater defense use of commercial software, however desirable, are effectively stymied.(17) Three problems are repeatedly indentified--complexity, delays, and legal uncertainties. Less clear perhaps is that these problems have a common source--the specification-oriented model of procurement previously discussed. After re-examining this model a bit, we will turn to three of the model's worst consequences, in the context of commercial software procurements.

3.1 WHY SPECS?

As commentators and procurement officials have repeatedly noted, current procurement statutes, regulations and practices are at least implicitly biased towards the acquisition of the truly unique--e.g., the fighter plane, obviously lacking a commercial counterpart--rather than the commercially unique--e.g., a particular software package available from one vendor. The orientation is towards the specification model described earlier. The potential user of a product, be that product a fighter plane or software, designs and describes the product in sufficient detail to permit competitive bidding from potential sellers. The orientation is away from surveying actual needs with an eye towards meeting them with products available in the commercial marketplace. This approach to acquisition practice, perfectly sensible with fighter planes, is less so with commercial software.

Particularly troubling in the case of commercial software is the rigidity of the processes, and, the complexity of resulting specifications. Allan V. Burman, Administrator of the Office of Federal Procurement Policy, generally and pithily summarizes both problems:

> "*The procedural framework outlined in CICA* (Competition in Contracting Act) *anticipates that market research, specifications development, and product evaluation processes will be performed in series.* For example, under CICA formal competition does not begin until the solicitation stage, and specifications development must be completed first. Accordingly, CICA does not allow acquisition officials to focus their specifications development efforts on a competitive field of products established on the basis of a product description and functional or performance specifications."(18)

Commenting on specifications, Burman notes, "A related view {to that of the desirability of separating specification development from market research} is that the benefits of competition are maximized when the Government states its needs in sufficient detail for anyone wanting to manufacture the product to be able to do so--thereby making price the only basis for competition."(19) Burman's summary of the problems echo Packard Commission findings, those of other high-level policy review bodies, and those of academic commentators.(20)

Demanding specification development before review of the commercial marketplace, and demanding specification in "manufacturing level" detail both directly contradict basic tenets of good commercial software acquisition practice, which emphasize early review of commercial products, continued interaction with potential vendors, and description of needs in functional, not design-oriented terms.(21) Worse, these demands have directly translated into three high barriers to greater defense use of commercial software products.

3.2 CONTRACT COMPLEXITY: ANNOYING FOR THE LARGE ORGANIZATION, TERRIFYING FOR SMALLER ONES

The extraordinary detail of various pre-award documents in the bidding process, bidders' responses in like detail, the legal complexity of the actual award documents, with cryptic references to DFAR's, FIRMR's, and the other inhabitants of the regulatory menagerie, are "business as usual" for both procuring organizations and for sophisticated bidders long accustomed to doing business with the federal government and the DoD in particular.

Alas, they are not so routine for many or perhaps even most software firms. As illustrated earlier, the software industry is composed of hundreds of relatively small, relatively young firms. Smaller software vendors typically lack sales organizations dedicated to federal or DoD sales, or federal sales subsidiaries. Frequently they are ill-prepared to respond adequately to bidding opportunities, to understand clearly their commitments in contracts, or to provide proper post-award compliance with cost or pricing data mandates or the like.(22)

The more sophisticated small vendors are likely to be aware of their limitations and not bid to supply products that might well be those exactly needed by the procuring organization. There is ample reason to believe that this sensible reticence is depriving the DoD of the very most innovative and potentially useful commercial products.(23)

3.3 TIME FRAMES: THE TECHNOLOGY MOVES FASTER THAN THE PROCUREMENT POSSE

The direct effects of complexity are perhaps more obvious and vexing to vendors than to purchasers. But indirect effects are obvious and deleterious to everyone.(24) Two such indirect effects are perhaps qualitatively the most severe, although difficult to quantify. First, because of the rigid lockstep of needs assessment, followed by spec design, followed by bidding, followed eventually by award, agencies are unable to take full advantages of rapid evolution in technology. This is particularly noticeable in commercial software procurements, occurring in the context of an industry whose private sector customers demand and obtain very rapid technical advances.

The second set of undesirable effects are the prolonged and bitter protest actions that are now the omnipresent chaperons of information technology procurements. The sheer complexity of the governing regulations and practices, and concomitant probability of possible or actual error despite the exercise of everyone's best efforts, plus the size of projected expenditures over time have converted recent major procurements (or more accurately, attempted procurements) into slow, complex minuets. Procuring agencies, various executive agencies, the courts, and detailed Congressional oversight, all have roles in the protest minuet.(25)

Currently the most publicized protests involve the procurement of entire systems, not commercial software alone. But the clear possibility of protests has a chilling effect on many software vendors, likely to be of modest size, and unable to incur either the delays or the out-of-pocket costs arising in the protest process. Equally vexing from the agency perspective are the extraordinary delays created by the protest process. The products are required to achieve the agency's mission. The effects of protest delay, perhaps hard to quantify in dollar terms, are certainly qualitatively apparent to program managers.

3.4 REGULATORY AMBIGUITY: A THORNY LEGAL THICKET FOR THE UNWARY

The specification model of procurement manifests itself unhelpfully, for commercial software procurements, in yet a third guise, in addition to those of complexity and delay. It crops up in critical ambiguity within the DFAR about what exactly defense agencies are able to do with commercial software and users guides, once acquired. Probably because of procurement bias towards competition in the "manufacturing" process of unique items, rather than relying on commercial acquisition techniques, the DFAR confusingly regulates software in the context of "rights in technical data."(26)

Although improved over its predecessor, this regulatory scheme blurs or overlooks key concepts: distinctions between documentation developed by the software vendor to aid its own processes, and documentation developed to help its customers use software; distinctions between software products and computer-based *information,* or databases, among many others. Excellent technical analyses of these issues in their previous and current guises are available and recounting them is beyond the scope of this paper.(27) These problems are acute concerns for commercial software vendors, which fear, with some reason, that ambiguities could lead to losses of additional sales to government customers, and perhaps others. Quantifying the consequences of such fears is impossible, but knowledgeable observers both within the Defense Department and industry are certain that such consequences exist, and that they deprive the defense applications of the best available technology. In the words of the Defense Science Board, "The Department of Defense recognizes that requiring contractors to sell or otherwise relinquish their legitimate proprietary rights in technical data as a condition for the award of a contract can have a detrimental impact on privately funded development and DoD's access to commercial technologies."(28)

4.0 BEYOND PROGRESS, BEYOND PITFALLS: THE FUTURE FACE OF DEFENSE ACQUISITION OF COMMERCIAL SOFTWARE

To this point we have reviewed progress in achieving the widely articulated policy goal of greater defense reliance on commercial software. We've reviewed the peculiar economics of the software industry, analogous to those of publishing, which make commercial software dramatically cheaper and more reliable than the alternatives. We've reviewed how the specification model of procurement is forced upon commercial software acquisitions, shifting what we've called the performance monkey onto the back of acquiring agencies, as well as making the entire process dauntingly complex, slow, and legally ambiguous.

In the final section of the paper we'll turn to the future, focusing on two areas. The first is practical techniques that the DoD and commercial software vendors can use right now to make the acquisition process work better for both of them. The second is areas where change beyond the control of current participants is needed, if commercial software is to assume the defense role that cost-benefit analysis uniformly suggests it ought.

4.1 SHORT TERM, EVERYONE'S IN THIS TOGETHER: WHAT AGENCIES AND VENDORS CAN DO RIGHT NOW TO MAKE COMMERCIAL SOFTWARE PROCUREMENTS MORE BEARABLE

The "chemistry" arising between agency procurement personnel and software vendor personnel can be especially complex. The former are clearly and properly accustomed to a formalized, rule-based, well-documented environment, and are well-suited for working effectively in such an environment.(29) Vendor personnel are, by contrast, often accustomed to an entrepreneurial, ad-hoc environment, befitting the relative youth and small firm size typifying the software industry. While both groups try hard to do a good job for their respective organizations, their interaction is less productive than it might be if each were more conscious of each others' circumstances

Understanding these circumstances and understanding each others' mandates, requires much better communication than generally seems to occur in commercial software procurements.(30) Talk is cheap and talk exhorting better communication is especially cheap. Nevertheless, there are clear benefits to be obtained by both vendors and procuring agencies through better communication in several steps of the procurement process.

Commercial software procurements proceed most smoothly from both the agency and vendor perspectives when each understands its own needs and the needs of the other. Informal surveys of vendor personnel and of DoD procurement personnel suggest that the former is the larger challenge for the DoD; the latter the larger challenge for software vendors.

For the procuring agency, the sheer number of people and functions involved in software procurement poses formidable communication challenges. Procurement professionals, including contracting officers, their technical representatives and others; technically-oriented prospective users of the products; mission-oriented prospective users; legal advisors; and agency or even higher level executives can all take a keen, if perhaps serial, interest in the acquisition. Many of these players have the effective power to slow or stall it, but rarely can one player alone effectively make an acquisition happen.

The quickest procurements generally seem to be those in which the frontline procurement personnel are able to rapidly communicate understandable information about the procurement to both agency technical and executive personnel and to the vendors; and in which technical personnel are able to clearly communicate understandable technical needs to procurement personnel. Defense acquisition personnel are generally more "comfortable" with hardware than with software.(31) This shows up in confusing and slow communication internally and with vendors.

In the context of reviewing governmental information technology strategies, the General Accounting Office strongly recommended implementing the concept of partnerships across technical and nontechnical groups to improve internal communication. "Within an organization, partnerships between program offices and technical groups, at all levels, can promote effective communication and cooperative working relationships. Agencies should establish such partnerships as a means of ending the artificial and damaging split between technical planning and program implementation."(32)

Another way to increase the level of "comfort" about software procurement and presumably improve communication about the issues might be to encourage more education of technical personnel about administrative and legal issues, and more education of procurement personnel about missions for which particular commercial software products are being sought. Agencies which perform large numbers of commercial software procurements might be in the best position to experiment with specialized training in software applications, for contracting officers and others in the process. The Defense Department's procurement personnel are academically very well educated.(33) Yet review of various DoD training and development programs reveals surprisingly little attention to continuing education in important new areas of technology, such as software.(34)

Another way to increase the comfort level and the efficiency of the communication process is creating logical sequences in the procurement process. Among the slowest commercial software acquisitions are those in which procurement, legal, technical, and executive review are sought *sequentially*, rather than *simultaneously*. Fastest and smoothest are those procurements in which such review proceed on parallel paths as far as possible.

Just as DoD personnel face unique challenges of *internal* communication, which ultimately impact vendors, vendors face unique challenges communicating *externally*, with the DoD. Software sales and marketing personnel, especially from smaller software vendors, are typically most familiar discussing their products with customer representatives who have some degree of technical understanding of the products, their intended uses, their competitors, and so on. In private-sector procurements, the customer's purchasing, legal, executive and other non-technical personnel often have far less sophisticated involvement in the sale than is often the case in DoD procurements. The more prominent role of these non-technical players can be baffling for an unsophisticated vendor.

Frankness by the contracting officer or her representative about who on her team will be doing what, and what the vendor should, as a practical matter, communicate to whom and when, is frequently necessary in commercial software procurements, given the relative lack of experience of many vendors. Similar frankness by the vendor, about who speaks with authority about what, can, for example, save the contracting officer endless hours of ultimately fruitless negotiation with vendor sales representatives who, for example cannot authoritatively speak for the vendor about legal issues.

4.2 LONG TERM: PROMISE US ANYTHING, BUT GIVE US FREEDOM FOR PROCUREMENT BUSINESS JUDGEMENT, AND CLARITY FOR THE DFAR

Summarized above are some communication techniques that can assist everyone in commercial software procurements, helping each participating organization in performing as quickly and as efficiently as possible. Beyond the reach of better communication, aided by better education, and better organization, are the fundamental methodological and legal hurdles that retard greater use of commercial software products.

No rational person can lightly suggest "reform" in DoD acquisition practices without heeding the sad historical fact that the current creaky and much criticized structure of regulations and practices was created, piecemeal, through well-intended previous reform efforts. A reasonable approach to all this might be leaving the current mess in place, on the theory everyone is better off with the devil known rather than the devil unknown. But attempted procurement reform must take its place with death and taxes as a certainty, so the status quo is probably not possible. Indeed, the "Commercial Products Acquisition Act of 1990," was proposed by the Administration in April 1990 to more fully implement Packard Commission goals.(35) Although both that proposal and an alternative (S. 1957) are firmly dead at the time of this paper, their resurrection or the reincarnation of their essences cannot be ruled out. A different, likely, but unpredictable source of changes in DoD software procurement practice is the increasing interest in developing cross-vendor technical standards, such as the Government Open System Interconnection Profile, or GOSIP.(36)

Proceeding under the seemingly safe assumption that statutory and/or regulatory modification of at least some current procurement practices is imminent, highlighted below are two areas where changes could result in considerably better acquisitions of commercial computer software, addressing many of the problem areas identified earlier in this paper.

The first is increasing the discretion that can be exercised by procurement personnel to obtain the best value, rather than focusing purely on price, and making sure such personnel are qualified to exercise such discretion. The second is authoritatively and sensibly identifying the rights that the Defense Department acquires in commercial software and its documentation.

4.21 CHEAP PRODUCTS AND GOOD VALUES: GIVING ACQUISITION PERSONNEL THE POWER TO CHOOSE

The ability of procurement personnel and Defense Department executives to exercise discretion, in any manner similar to that employed in private-sector procurements, is severely limited by statute, by the DFAR's and related regulations, and by the procurement culture. Again quoting Allen Burman, "{C}ontracting officials are discouraged from exercising business judgement. Instead, they are driven, to adopt, early in the acquisition process, detailed specifications defining the agency's minimum needs."(37)

This discouragement reflects a laudable policy goal of encouraging competition on objective criteria. But has the paradoxical and presumably unintended effect, in acquiring commercial software, of making the competition come both too *late* --after the specifications have been cast in procurement concrete--and too *early* --before the procuring agency can work interactively with vendors to survey the commercial marketplace, assessing how commercial products might (or might not) meet the agency's needs.

Careful attention, with both government and industry input, needs to be paid to developing a regulatory scheme which gives all competent vendors an opportunity to work with the DoD to help define needs in light of commercial offerings, and not merely an opportunity to compete, in some academic sense, after those needs have been precisely documented.

Granting greater discretion for interacting with potential vendors *permits* (but of course does not ensure) the solution of the difficulties flowing out of the current specification-oriented procurement model: contractual complexity, inordinate delay, and legal confusion, although the latter point can and must, if the confusion is to be dispelled, be addressed independently.

But granting the legal authority to exercise discretion alone will not aid in the informed exercise of that discretion. Procurement executives and industry must pay closer attention to the training and education of front-line personnel, on both the DoD and vendor side. Cooperative training efforts, in which defense procurement personnel are given better opportunities to understand the commercial software market, while their industry counterparts come to understand the regulatory and administrative structure of the agencies with which they work, would aid in the informed exercise of newly-created procurement discretion.

4.22 GETTING CLEARER, BEFORE THE DEAL IS INKED, ABOUT WHO WILL HAVE WHAT, AFTER THE DEAL IS INKED

Commercial software sales to defense agencies are unlikely to reach their full potential until the elimination of lingering confusion about exactly what rights the DoD acquires in the software and documentation, and how they acquire those rights. Dispelling confusion in this area, which no one suggests has desirable consequences and does not seem to raise any publicly voiced policy issues, has bogged down. Regulatory change has been derailed into a swamp of less clear-cut policies about the nature of rights acquired and needed in products whose development was funded in whole or in part by the government itself, which is a completely separate series of issues. Unraveling the discussion of these separate issues must be a first step if timely DFAR clarification of commercial software rights is to be forthcoming.

5.0 CONCLUSION

We have briefly surveyed 1990's issues in DoD acquisition of commercial software. In the 1980's, commercial software edged towards a greater role in defense systems, strenuously urged on by a host of defense procurement commentators and study commissions. A review of the cost structure of commercial software development, perhaps not generally understood outside the software industry, revealed the sources of its products' tremendous and widely-recognized cost and performance advantages.

These advantages notwithstanding, greater DoD use of commercial software is now haunted and hobbled by procurement complexity, delay, and legal ambiguity. These unwelcome companions are the consequences of procurement practices oriented towards the product development, rather than towards sophisticated reliance upon existing commercial products.

We reviewed how the ghosts can be kept at bay by better communication between and within vendors and acquiring agencies. But fully banishing them will required more throughgoing changes: granting procurement personnel greater discretion to exercise their good judgment, and removing DFAR confusion about what exactly the DoD can do with commercial software, once acquired.

ENDNOTES

(1)The author thanks Dianne Johnson, Nancy Valmassoi, and Alice Hyman for stimulating discussions of these issues; and Fran Ashford, Dorothy King, and Barbara Sessions for valuable research and technical assistance with this paper. The opinions presented here are those of the author and not necessarily those of organizations with which the author is affiliated.

(2) *E.g.*, the President's Blue Ribbon Commission on Defense Management, *A Quest for Excellence* (1986) (cited hereinafter as the *Packard Commission Report);* an excellent history of the idea in the 1970's appears in the *Packard Commission Report's*, Appendix H, "Expanding the Use of Commercial Products and 'Commercial-Style' Acquisition Techniques in Defense Procurement: A Proposed Legal Framework," 103 (cited hereinafter as "Packard Commission Report, Appendix H").

(3) The concept of commerciality is far more complex than this simple sentence suggests "Packard Commission Report, Appendix H," 78.

(4) Office of the Under Secretary of Defense for Acquisition, *Report of the Defense Science Board on Use of Commercial Components in Military Equipment*, v, (1989); (cited hereinafter as *Defense Science Board Report).*

(5) *E.g.*, Samuelson, *Toward a Reform of the Defense Department Software Acquisition Policy* (1986); Martin, *Seeking the Balance Between Government and Industry Interests in Software Acquisitions, Volume I: A Basis for Reconciling DoD and Industry Needs for Rights in Software*, (1987).

(6) Staff Study, Subcommittee on Investigation and Oversight, Committee of Science, Space and Technology, U.S. House of Representatives, One Hundred First Congress, Second Session, *Bugs in the Program: Problems in Federal Government Computer Software Development and Regulation*, (cited hereinafter as *Bugs).*

(7) Id. n. 2.

(8) McGraw-Hill, Incorporated, *Datapro Directory of Software*, "Vendor/Product" Index.

(9) "Software's Heavy Hitters," *Information Week*, April 23, 1990, 46.

(10) Id.

(11) Software Working Group, Science and Technology Committee, Defense Acquisition Board, *Department of Defense Software Master Plan, Volume I: Plan of Action* (Preliminary Draft, February 1990), 21; (cited hereinafter as *Software Master Plan).*

(12) McGraw-Hill, Incorporated, *Datapro Reports on Software,* "Buyer's Guide to Software Acquisition" SW 10-000AE-104 (1989); (cited hereinafter as "Buyer's Guide to Software Acquisition").

(13) *Bugs*, 12-19.

(14) "Buyer's Guide to Software Acquisition," SW 10-000AE-104.

(15) See "Packard Commission Report, Appendix H," 83.

(16) DoD FAR Supplement 227.481-2(3).

(17) Cf. *"Defense Science Board Report,* (commercial software industry's technical change moved in the 1980's "at a pace completely outstripping the military's ability to assimilate it,").

(18) "Statement of Allen V. Burman before Oversight of Government Management Subcommittee of the Governmental Affairs Committee, United States Senate, April 26, 1990," 6; (emphasis original); (cited hereinafter as "Burman").

(19) "Burman," 3.

(20) "Packard Commission Report, Appendix H." 85; *Bugs, 8;* Williams, "Competitive Bidding: Department of Defense and Private Sector Practices," *Journal of Purchasing and Materials Management,* Fall 1988, 29.

(21) See "Buyer's Guide to Software Acquisition," SW 10-000AE-106-111.

(22) Cf. "Burman," 2 ("{B}usinesses readily acknowledge that the most unique and onerous of the provisions included in Government contracts stem from the Government's specification development and pricing practices"); Cf. *Defense Science Board Report,* 9 ("The current acquisition system is...{b}urdened with law and regulation that far exceeds what is the norm for commercial contracting").

(23) Cf. "Burman," 5 ("{Abandonment of the government market by commercial suppliers} limits the extent to which Government missions can benefit from agency acquisition of commercial products..."); Cf. *Defense Science Board Report, 9* ("Corporations are increasingly making decisions to severely restrict their government contracting...").

(24) "ADAPSO Federal IRM Survey Sheds Light on Importance of System Integration Trend," *Federal Computer Market Report,* August 27, 1990, 3.

(25) Among the most currently notorious protests at the time of the writing of this paper is the Interior Department's attempted workstation award to Data General. See "Data General Wins, Loses, Wins and May Lose Again Seminal $127 Million Contract," *Federal Computer Market Report,* November 12, 1990, 1. With some understatement, the article characterizes the issues as "many and varied."

(26) *E.g.,* DoD FAR Supplement, Subpart 227.4, "Technical Data, Other Data, Computer Software, and Copyrights;" 52.227-7013.

(27) *E.g.,* Greenberger, "Rights-in-Data Policies Affecting Department of Defense Acquisition of Computer Software and Related Products," IX *Computer Law Journal,* 447 (1989): Davis, "Acquisition of Rights in Computer Software by the Department of Defense," 17 *Public Contract Law Journal 77 (1987):* Samuelson, "Understanding the Implications of Selling Rights in Software to the Defense Department: a Journey Through the Regulatory Maze;" (Carnegie-Mellon University, Software Engineering Institute, Technical Memorandum SEI-86-TM3, March 1986.)

(28) *Defense Sciences Board Report*, 16.

(29) See Michael G. Krause, "Characteristics of Acquisition Personnel," *Proceedings, 1989 Acquisition Research Symposium*, 281.

(30) *Software Master Plan, 7.*

(31) *Software Master Plan, 9.*

(32) United States General Accounting Office, Information Management and Technology Division, *Meeting the Government's Technology Challenge: Results of a GAO Symposium, 7 (1990).*

(33) Stewart, *Managing Millions: An Inside Look at High-Tech Government Spending,* 168 (1988).

(34) *The Quality and Professionalism of the Acquisition Workforce: Report of the Investigations Subcommittee of the Committee on Armed Services, House of Representatives, One Hundred First Congress, Second Session*, May, 1990, Appendix, pp. 505-775.

(35) Transmittal letter of Secretary Cheney to Speaker Foley, April 5, 1990.

(36) *Defense Science Board Report, 7.*

(37) "Burman," 3.

SOFTWARE ACQUISITION MANAGER (SAM)

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Modern Technologies Corporation

ABSTRACT

MTC's Software Acquisition Manager (SAM) is a computer program model using artifical intelligence precepts. It supports acquisition managers by assessing development risks, determining development complexity, and identifying the "health" of each development event and product on a success to failure scale. The model provides assessment reports and alert notices based upon the "health" scale of each event, and of the software system based upon the events in combination.

The acquisition events and the impact of each on development are specified by the user at procurement inception and can be modified at any time during the acquisition process. To operate SAM the user simply answers a few computer generated questions about the software development process, supplies schedule data, and provides event evaluation results. The "expert environment" then takes over, emitting success-failure judgements and issuing indicators of needed acquisition actions. SAM is also a planning and analysis tool through its gaming and forward-backward looking capabilities.

INTRODUCTION

Software acquisition within DoD has resulted in fewer than 25% of the developed products being usable for their intended purpose. Since the DoD acquisition process is sound, the failure must be ascribed to faulty implementation of the process. The primary faults are threefold: 1) lack of development problem detection before it severely impacts the build process; 2) Inability to forecast development problem impacts; and 3) inadequate corrective and preventive actions. Correcting these three faults would tend to tip the software success-failure percentage from 25-75 toward 75-25.

To moderate the effects of the foregoing faults and to assist in improving the software development yield, we have constructed a proof-of-concept model that allows Air Force acquisition managers to assess development risks, determine development complexity, and identify the "health" of each development event and product. The proof-of-concept is based on the software development process of DOD-STD-2167. That standard was chosen because it is the basis of real-time software development and because the number of events are manageable, yet, they cover all program areas from requirements development to program management transfer.

BACKGROUND

Over the past ten years, software embedded in weapon systems has become more mission critical with on-board memory requirements increasing exponentially. Figure 1, supplied by the Air Force Aeronautical Systems Division, Engineering Deputate (ASD/EN), reflects that condition. DoD has responded to this increased prominence by providing development guidance through the following:

• DOD-STD-2167A, "Defense System Software Development".[1]

• Air Force Systems Command's pamphlet for "Software Management Indicators"[2] and "Software Quality Indicators".[3]

• Aeronautical Systems Division's "Software Development Capability/Capacity Review"[4] for pre-award assessments of a potential contractor's software capabilities.

• The Department of Defense Software Engineering Institute's software maturity evaluation methodology, "A Method For Assessing the Software Engineering Capability of Contractors".[5]

• Air Force Systems Command's pamphlet for "Software Risk Abatement".[6]

These (and other similar guidance from Navy and Army sources)--when conscientiously employed--materially improve the acquisition process in their area of focus. The major problem, however--the acquisition management process for ensuring useable software--, still haunts the software development process.

Though the foregoing development methods have contributed to the improvement of acquisition management, it is not clear how they fit together, and no effort has been made to synthesize them. These methods are, in most of their applications, complex.

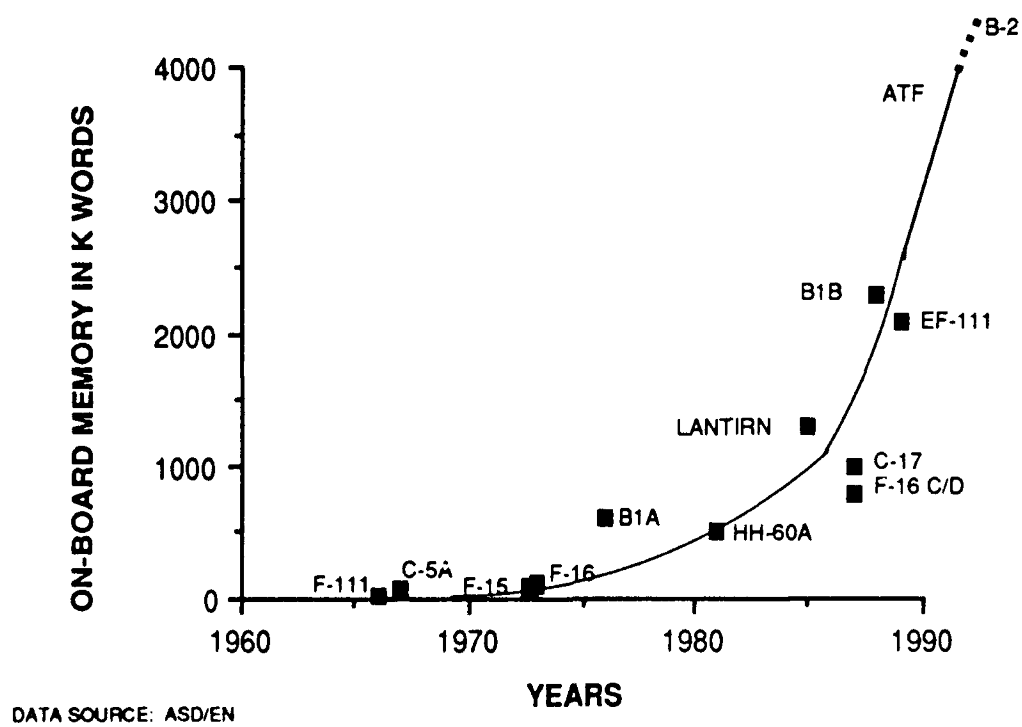


Figure 1: Embedded Software Memory

Consequently, they require significant software acquisition experience to be used successfully.

CONCEPTUAL FOUNDATIONS

The crux of the problem is that the scope and complexity of software acquisition management is expanding while the availability of experienced software acquisition and development managers is limited. The discipline needs, as a minimum, a system that will support less experienced managers in:

• Assessing software development risk on a real-time and continuing basis.

• Measuring developmental complexity of the software acquisition and scoping its impact on each event and product in the acquisition sequence.

• Supporting the control and evaluation of every event or product.

• Identifying and assessing and maintaining action item tracking and control.

• Reducing development cost through *real-time* intelligent tailoring and look-ahead analysis.

• Analyzing what-if impacts on software development success.

Design of a support structure encompassing the above items must be tightly woven into the software development process. Examination of that process exhibits two basic thrusts as depicted in Figure 2: 1) the development process itself, and 2) the events and products composing that development. The focus of the software acquisition

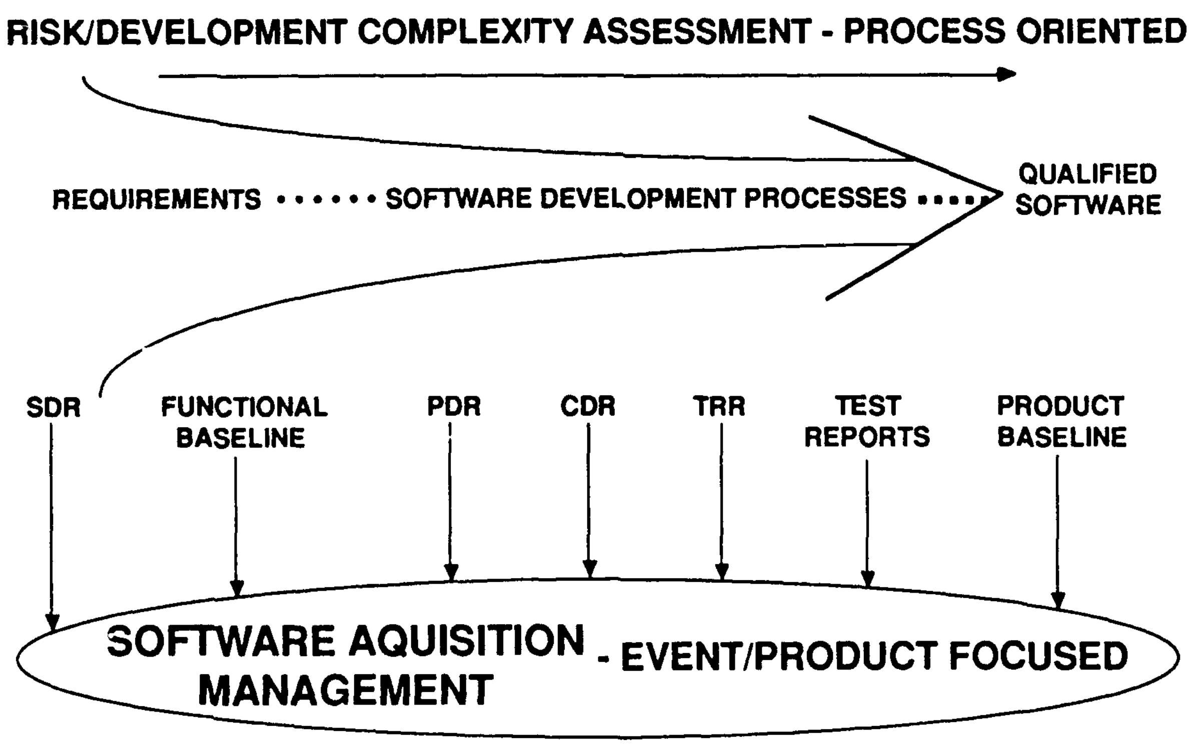


Figure 2: Software Acquisition Focus

process is based on the concept that good software development depends on a good development process, and that if the process is adhered to, quality products will follow.

The key to building an acquisition support tool for use by software acquisition managers lies in merging the two foregoing thrusts. This goal is realized through an interactive acquisition management core program. The SAM core, as shown in Figure 3, is simultaneously interactive with the risk analysis process, the Action Item Processor, and with the one who manages the software acquisition.

SAM PROCESS

SAM is a rule based, acquisition management support tool which is designed to assist the software acquisition manager at any point throughout the acquisition process. It is employable for detailed acquisition analysis at either the event\product level or at the system level. Moreover, it can operate in a predictive mode to assist the manager in forestalling problems before they occur, or in rectifying them at the earliest possible point in the development.

Figure 4 represents the generalized process of SAM. It is composed of a system level and a development event/product level. Acquisition data derived from system level analyses can be used as stand-alone data for specific evaluation of project risk or development complexity; or it can be further used in the event/product process during the course of development.

System Level. The system level application of SAM has three interacting

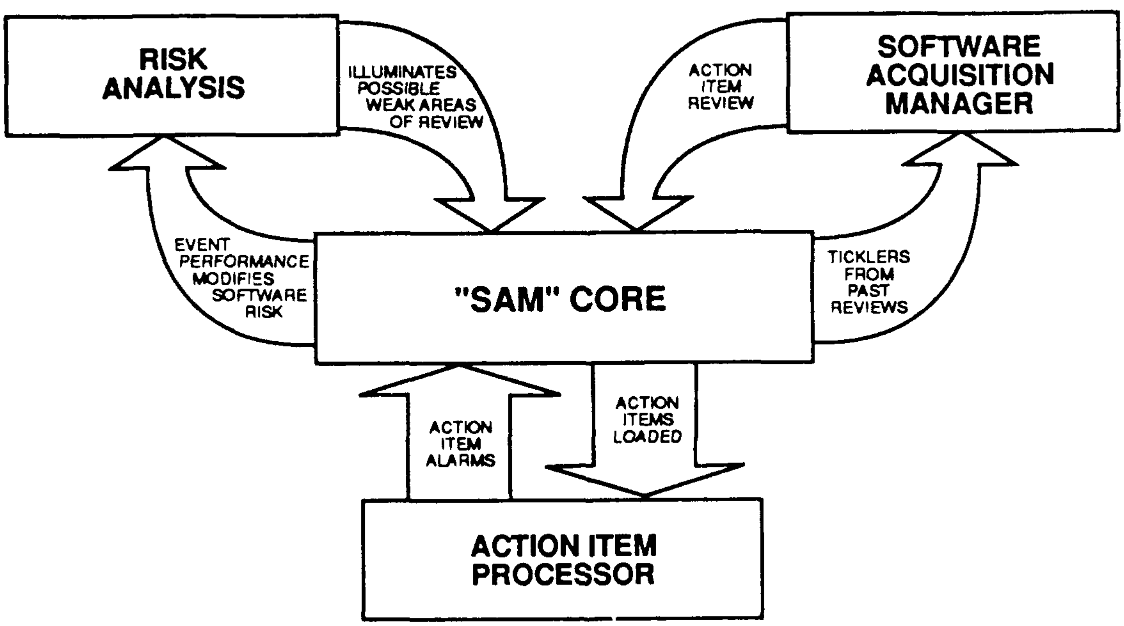


Figure 3: SAM Interactive Structure

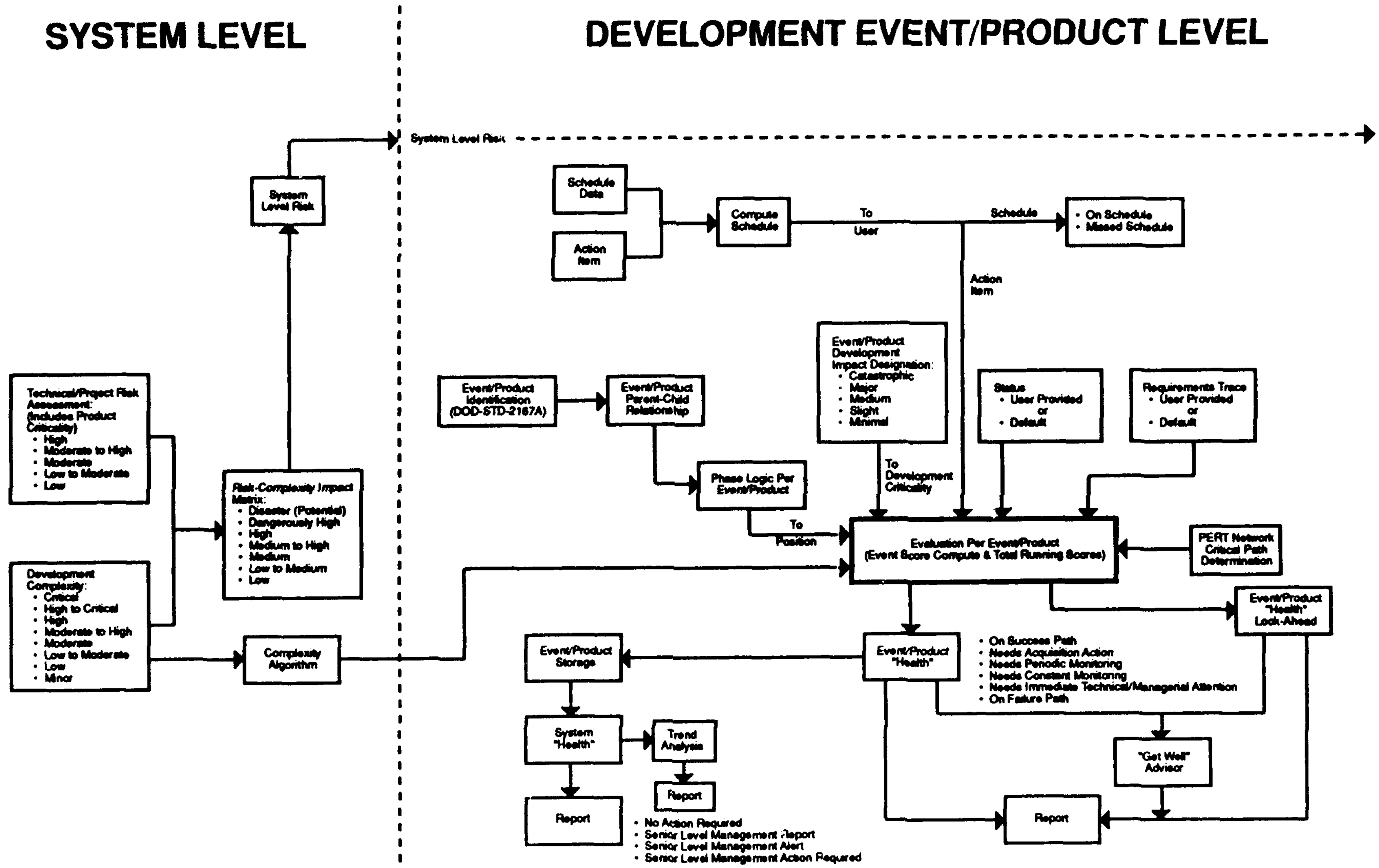


Figure 4: Software Acquisition Manager Process

elements: project risk assessment; development complexity computation; and a risk-complexity impact matrix. The latter element is used to combine the effects of the former into a single system level risk.

Project Risk Assessment: Invoking the risk assessment process follows an initial screening which asks questions about the software criticality (e.g., could cause loss of life, size and cost of the software for the weapon system, and how essential the software is to mission objectives). Once it is determined that the software is critical, risk evaluation is activated. Figure 5 outlines the risk evaluation structure used. The structure follows a metric type decomposition which progressively reduces each risk element to measurable criteria.

The risk elements and their factor composition are listed in Figure 6. Each factor undergoes further reduction to its integral criteria which, in turn, structures its measurement strategy. Also appended to each factor is a weight representing its impact on risk assessment.

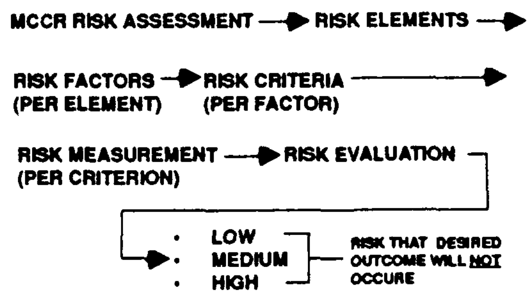


Figure 5: Risk Evaluation Structure

After the risk data has been acquired, a score is computed by normalizing the risk assignment and weight. The data is processed through a software routine

REQUIREMENTS
- COMPLETE
- CONSISTENT
- UNAMBIGUOUS
- CRITICALITY
- COMPLEXITY
- TRACEABILITY
- STABILITY
- SIZE
- TECHNOLOGY
- CONSTRAINTS

DEVELOPMENT PROCESS
- REQUIREMENTS
- SYSTEM INTERFACES
- STRUCTURED PROCESS
- STANDARDS
- DESIGN
- CONTROLS
- QUALITY
- QUALIFICATION
- DOCUMENTATION
- BASELINES
- PERSONNEL
- DEVELOPMENT SUPPORT

TECHNOLOGY
- APPLICATION
- MATURITY
- APPLICATION EXPERIENCE
- COMPUTER HARDWARE
- OPERATIONAL SOFTWARE
- RESOURCE CONSTRAINTS
- DEVELOPMENT SUPPORT
- SOFTWARE/HARDWARE TOOLS
- PERSONNEL

PRODUCT QUALIFICATION
- REQUIREMENTS TRACE
- VALIDATION CONFORMANCE
- VALIDATION METHODS
- TEST PLANS/PROCEDURES/ REPORTS
- STRESS/BOUNDARY TESTING
- CONTROLS
- AUDITS
- TEST PROMOTION/DEMOTION PROCESS
- QA PARTICIPATION

PERSONNEL
- EXPERTISE
- MIX
- EXPERIENCE
- SUFFICIENCY OF NUMBERS
- AVAILABILITY
- TURNOVER/RETENTION
- PERSONNEL MANAGEMENT

SCHEDULE DRIVERS
- SYSTEM DEFINITION
- SYSTEM STABILITY
- COMPLEXITY
- BASELINES
- CONTRACTUAL
- DEVELOPMENT TOOLS
- FINANCIAL

COST DRIVERS
- REQUIREMENTS
- SIZE
- APPLICATION
- TECHNOLOGY
- REUSABLE SOFTWARE
- LANGUAGE
- FACILITIES (DEVELOPMENT & TEST)
- CONFIGURATION MANAGEMENT

Figure 6: Risk Factor Per Risk Element

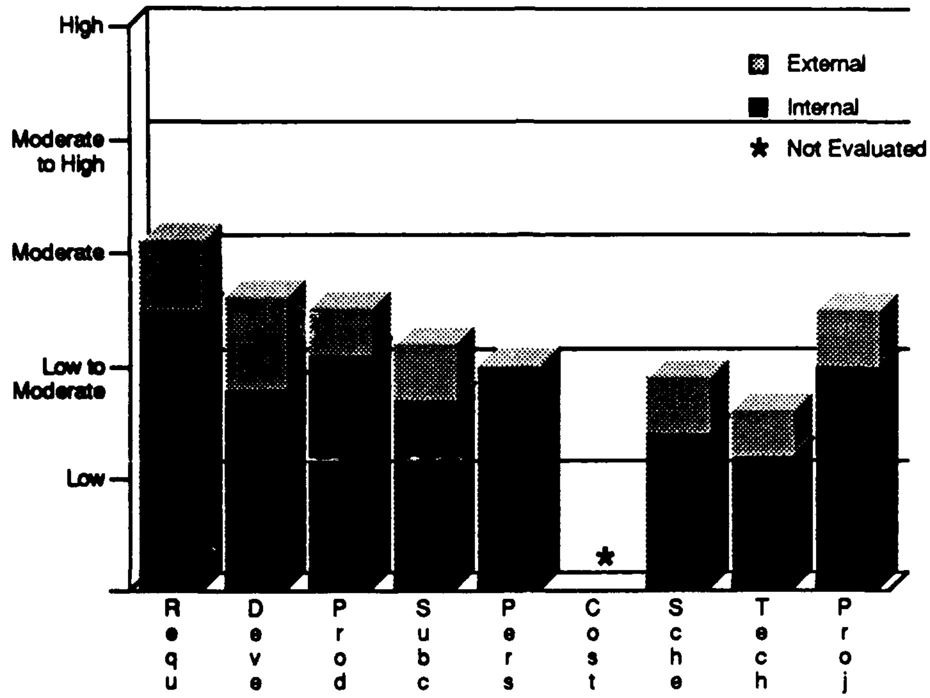


Figure 7: Software Risk Determination

which generates a bar graph profile of the risk. Figure 7 is a sample of the profile. The abscissa represents the risk elements with the ordinate representing two different measurements; 1) internal to the development, and 2) specifications external to the project that impact the risk assessment of each element. This allows risk assignment in cases where a prime contractor employs subcontractors or when teams of contractors are involved in a single software development.

Development Complexity: Development complexity is derived by assessing the difficulty of the software requirements from a system level perspective. Table 1 lists the complexity scaling elements that are measured. Each of the scaling elements is divided into five factors for measuring its complexity. After normalizing the measurements, as done for the risk elements, a system level development complexity score is computed in a fashion similar to that of the risk assessment. This data is used with the risk assessment data to determine the system level risk. In addition, development complexity has a multiplier effect on the event/product criticality assigned by the user for a software acquisition.

COMPLEXITY SCALING ELEMENTS

A. Functional complexity
B. Originality
C. Span of operations
D. Degree of generality
E. Change in scope/objective
F. Size: source Lines of Code
G. Critical factors:
  a. mission critical
  b. technical risk
  c. cost/schedule risk
H. Interface complexity
I. Database complexity
J. Integration complexity
K. Complexity of security requirements
L. Certification requirements
M. Probability of change
N. Development location
O. Software quality factor
R. Operational impact
Q. Personnel assigned to software development
R. Software development cost
S. Average change response time required
T. Timing and synchronization required
U. Programming language
V. Concurrent hardware/software development

Table 1: Complexity Scaling Elements

Development Event/Product Level. The development event process is the heart of what may be termed a "health" advisor. Here "health" applies to the success condition of an event, or in combination, to the system development, at a particular time. While Figure 4 provides the essential details of the development event process in determining software acquisition "health", Figure 8 represents the adaptation of that process, and shows the operator and user inputs and actions necessary to activate SAM's query capability.

Set-Up: SAM is initialized with the acquisition events specific to a particular procurement, each associated with its development impact criticality. The parent-child interrelationship of each event is also set-up along with schedule data. As shown in Figure 8 the events and their development criticality, if not specified, will default to pre-set values. Further, at this point, the risk and development complexity assessments should be performed to support subsequent SAM processing.

User Interface: A user operates SAM by providing inputs, requesting specific types of processes, and querying the process for the particular items shown in Figure 8. It should be stressed that SAM is adaptable in "real-time" to the acquisition activity. Any aspect may be changed or a process initiated at any point of the acquisition cycle.

Reports: SAM is capable of graduated reporting levels from detailed analysis data and query type outputs, to senior level management summaries and alerts for red, yellow, green, and blue conditions.

"Health" Score. The "health" score of an event--and in summation, the overall development--is a gradation between failure and success. A dominant factor

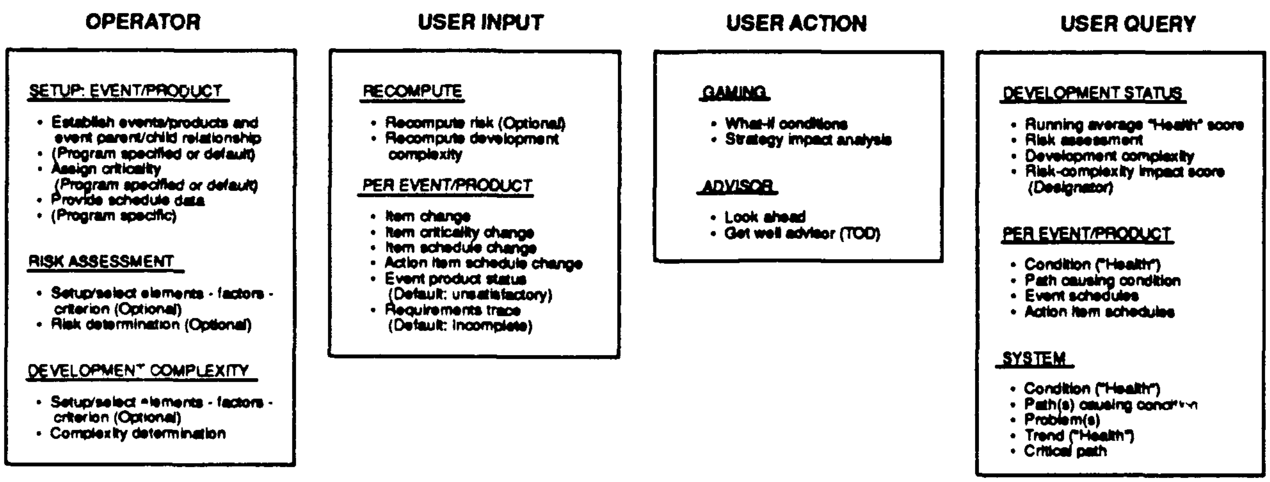


Figure 8: Software Acquisition Manager Adaptation

driving the scoring is the impact of an event on development (i.e., the measure of its criticality to the product success).

An event is measured for its properties at a specified point in time during development, and that measurement establishes its real-time "health". An event's "health" status is derived as a function of the following aspects:

• Development Criticality - impact of the event on development.

• Position - the event's development location in relationship to its "parents" and "children".

• Status - the event evaluation results.

• Requirements Trace - accountability for requirements throughout development.

• Schedule - event due date.

• Critical Path - as defined in a PERT network concept.

• Action Items - an essential correction necessary to rectify an event problem.

APPLICATIONS AND EXPERIENCE

Portions of SAM have been applied independently of the complete system. SAM's modular design permits singular application of risk assessment, development complexity, schedule tracking, action item tracking, and the "health" analysis. Future functions will also be modularized to assist in their separate application.

In varying degrees, aspects of SAM and the SAM concepts have been used on the following programs:

• B-2 Bomber - The primary application is a risk assessment of various contractor's development. It has also included a limited set of the development complexity items.

• Advanced Cruise Missile - The principle thrust currently is the risk assessment module, however, the entire SAM process is being readied for application.

• Low Altitude Navigation Targeting Infrared for Night (LANTIRN) - SAM provided analysis and support for start-up of the Paperless LANTIRN Automated Depot (PLAD) program.

• U.S. Army Aviation Systems Command (AVSCOM) - The SAM concept and prototype were significant contributors in establishing an innovative Independent Verification and Validation (IV&V) and Software Quality Assurance (S Q A) approach for AVSCOM acquisitions. We were the successful bidder on that competitive procurement.

• Special Operations Forces (SOF) Aircrew Training System (ATS) - SAM's event tracking capability is under study for application to the SOF ATS software procurements.

MANAGEMENT IMPLICATIONS

Software acquisition management expertise is a rare commodity. SAM is designed to accommodate that lack of expertise. It incorporates the management process into a single software package featuring easy use by all levels of management. The aspects of SAM which are most beneficial to a system acquisition manager are briefly listed below.

• Acquisition Data Repository - SAM is host to all essential software acquisition data during the procurement phase. At the point that program management is transferred to the user/supporter function, the acquisition data is archived. Those archived data can be used later as a basis for developing acquisition improvements.

• Acquisition Tracking System - The procurement data used in the SAM functions provide the basis for a software acquisition tracking system. SAM provides this capability for schedule tracking, action item tracking, and event network-critical path designations.

• *Acquisition* Evaluation System - With the menu displays, the system manager can access and/or run all basic portions of SAM either independently or as an integrated whole. The facility exists for the manager to gain a complete current acquisition condition and the path which led to that condition. The very core of this capability is that SAM incorporates the expertise and skills of professional software acquisition managers, making these available to the manager through a set of menus, questions, and rules.

• On-Line - All essential data is available in a "real-time" sense during any acquisition situation. This expands to the use of SAM for a current assessment of both the risk of failure, and the detection of any situation which could drive the development into a failure condition.

• Problem Analyzer and Advisor - SAM is capable of tracking back through events and data, and resurrecting situations which have contributed to high development risk. Additionally, SAM can locate potential problems that are looming, and can indicate trends toward failure. Companion to this is an advisor function that suggests what action could be taken to reduce the risk of failure.

• Strategy Development - SAM provides the manager with a complete picture of the software acquisition function in a single, interactive package with analysis capability. This allows the manager to experiment with various acquisition strategies and to maximize the probability of success. During that exercise, the manager can also maximize personnel expertise assignments. This is particularly valuable in disciplines that are in short supply (e.g., mission critical computer resources experts).

CONCLUSION AND FUTURE PLANS

In summary, SAM provides problem alerts when the acquisition process strays from a "success path". It also looks ahead and alerts on possible forthcoming problems and, if requested, will suggest "get well" actions. These services are performed at the event level, therefore, one of the major powers of SAM is in support of the novice clerk through to the senior program manager, providing information specific to each level.

SAM can be classified into a twofold adaptation: 1) a software acquisition management tool; and 2) a "what if" gaming tool. The former is for "real-time" acquisition, whereas, the latter is for developing strategy either prior to an acquisition situation or as procurement requirements or constraints change during acquisition. Data from past acquisitions could also be resurrected to study improvements in both the concept and accuracy of SAM.

SAM is still in the prototype phase using Clipper as its programming environment. We have recently initiated a task to transfer it to a knowledge base environment employing an inference engine. During the course of that task a critical path algorithm (e.g., PERT) will be added to the SAM capabilities.

The most pressing improvement is the research to define and implement a requirements fidelity module. This means devising a method and process to parse system requirements for their consistency, completeness, ambiguity, and measurability. When that module addition is functioning, a confidence factor approach and its incorporation will be investigated. This latter task will also address "fuzzy logic" concepts.

These plans are very ambitious and broad in scope. We, therefore, solicit DoD and industry comments, ideas, suggestions, critiques, and possible participation in the future development of SAM.

ENDNOTES

1/ DOD-STD-2167A, 29 February 1988, Defense System Software Development. See also the associated DOD-STD-2168, 29 April 1988, Defense System Software Quality Program

2/ AFSC Pamphlet 800-43, 31 January 1986, Software Management Indicators.

3/ AFSC Pamphlet 800-14, 20 January 1987, Software Quality Indicators.

4/ ASD Pamphlet 800-5, 10 September 1987, Software Development Capability/Capacity review, OPR: ASD/EN/CRFP (Philip S. Babel).

5/ CMU/SEI-87-TR-23, also ESD-TR-87-166, September 1987, A Method for Assessing the Software Engineering Capability of Contractors (preliminary version). This report was prepared for the Software Engineering Joint Program Office (Electronics Systems Division, ESD/XRS) by Carnegie-Mellon University.

6/ AFSC Pamphlet 800-45, June 1987, Software Risk Abatement (draft).

AUTOMATED PROCUREMENT

ANALYSIS OF AUTOMATED PROCUREMENT ALGORITHMS FOR ELECTRONIC DATA INTERCHANGE SYSTEMS

Mr. Richard L. Cromley, Defense Personnel Support Center

ABSTRACT

Electronic data interchange (EDI) technology is becoming more and more widely used in acquisition programs and systems. Using EDI, an organization and its customers and suppliers are able to automate the process of soliciting and receiving offers, awarding contracts, and invoicing and making payments via electronic transmission. An important component of the process is the ability to embed algorithms that allow for automated selection of firms to solicit electronically. These algorithms directly affect the performance of the system in terms of pricing, manual review requirements, and leadtime.

An analysis was undertaken to determine the performance level of such algorithms. A simulation model was developed based on an EDI acquisition system currently being used to purchase medical supplies at the Defense Personnel Support Center, Defense Logistics Agency. Data extracted from over 15,000 individual award actions for over 2,500 different items was used to build the model.

Performance criteria included the variability in award price level, cost to procure, manual intervention required in terms of having to review potential awards due to pricing problems, resolicitation requirements, and leadtime. Performance of the current system algorithm is compared to the performance of alternative algorithms.

INTRODUCTION

Background. Electronic data interchange (EDI) technology is rapidly being applied in numerous business activities. The procurement process is one area where EDI systems can be used to gain efficiencies in terms of shorter lead times, reduced manpower needs and increased accuracy of documents.

In a typical EDI procurement system, incoming purchase requests can automatically be converted to request for quotations. The system selects firms to solicit and then transmits the requests to these firms. In turn, industry responds with bid or quote transmissions. The system then evaluates the bids, selects a firm(s) for award and issues a delivery order or contract which is then transmitted to the selected firm. All of these tasks are performed with little or no employee intervention.

These systems are very well suited for procurement activities where there are a large number of transactions for a large number of standard items. Typically the dollar value of the transaction is small. Without an automated EDI system, an extreme amount of manpower would be needed to process documents, contact firms (by mail, fax or phone), select contract awards and notify winning firms.

In an automated EDI procurement system, the algorithms embedded in the system for the selection of firms to be solicited and the evaluation of bids received may play an important role in helping to insure reasonableness and stability of pricing within the system. In other words, when an item is purchased through the system, we want to insure that a fair price is paid and that the price varies only with price movements in the marketplace. If this is not the case, the integrity of the system is in question and excessive human intervention may be required for monitoring purposes.

Scope. In this paper we focus on algorithms for selection of firms for solicitation. We are primarily interested in the pricing performance of the algorithms but other performance measurements such as the amount of human intervention required and the need for resoliciting due to nonresponse by firms are also examined. Procurement data obtained from an automated EDI system currently being used by the Defense Personnel Support Center (a component of Defense Logistics Agency, Department of Defense) is used as a basis to test the performance of the embedded algorithm as well as alternative algorithms.

CONCEPTUAL FOUNDATIONS

The procurement process has been examined in economic theory using competitive bidding models. Holt[1] describes one model of bidding for procurement contracts defined as a "discriminatory auction" in which there is one submission of a sealed bid from a number of firms and low bidder receives the procurement contract. He derives an equilibrium bidding strategy mathematically using a series of utility, density and probability density functions. An important variable affecting equilibrium (or the low bid received) in the model, one that can be effected by the procuring agent, is the number of bidders. Holt makes an important conclusion from the model; as the number of bidders increase, all bidders bid for lower profits, thus, procurement cost is a decreasing function of the number of bidders.

Empirical studies by Kuhlman and Johnson[2], and Brannman, Klein, and Weiss[3] support this theoretical contention. The Kuhlman study, based on an analysis of bid data for state highway construction contracts, showed that an increase in the number of bidders resulted in a lower winning bid. The Brannman study, based on an analysis of bid data for tax-exempt bonds, offshore oil tracts and National Forest timber, also showed that in all cases more bidders meant significantly lower winning bids.

Thus, theory indicates that a procurement system should attempt to solicit bids from the greatest number of firms available. Unfortunately, as the number of firms solicited increases, so does the cost to solicit (e.g., manpower, telephone, fax) and the time to receive responses (therefore increasing the leadtime to purchase which increases operating cost). In addition, research indicates that procurement cost decreases at a decreasing rate as the number of competitors increase[4]. At some point, solicitation costs would exceed any decrease in procurement cost.

Given the above information, a procurement system objective would be to find the number of firms to solicit that yields the maximum return where return is measured as the difference between the reduction in procurement cost and the increase in the cost to solicit.

METHODOLOGY

Data. Procurement data for a five month period from May 1990 to September 1990 was extracted from the EDI system. The data included item, bid prices, award prices, quantity, firm, date, and days to respond to the solicitation. Bid and award prices were adjusted for inflation.

All data was restricted to those items that had been purchased at least 6 times during the period in order to insure that any observed variability in award price was valid and not random. The resulting data represented 15,463 awards for 2,831 unique items. Bid data was restricted to those items who had at least 12 bids recorded against it for the same reason. The data represented 30,000 individual bids for 533 unique items from 48 firms. The number of bids for individual firm ranged from 6 to in excess of 1900.

Simulation Model. In order to test the performance of alternative algorithms, a model was written in PC SIMSCRIPT to simulate the automated procurement system. Distributions and probabilities for the model were obtained from the empirical data. This included the probability of a firm responding with a nonzero bid (68 % chance), the distribution of the number of days firms take to respond to a solicitation (ranging from the same day to in excess of 7 days), and the distribution of individual bid ratios for each firm.

The model generates a solicitation, selects firm to solicit based on the algorithm being tested, receives and evaluates the corresponding bids and records performance information described in the following paragraphs. In the event there are no responses to a solicitation (based on the probability of a firm responding), another solicitation is generated. If there are still no responses, the solicitation is cancelled and appropriate statistics are recorded.

Measurements of Performance

Pricing and Cost to Award. In order to compare award pricing patterns for the whole system (i.e., price variability across all items), the following measurement was derived: form a ratio by taking each award price and divide by the lowest (best) award price during the period for the item in question. In an ideal system, the average of all award ratios would equal 1.00 indicating that all items could be purchased at any time at the best price available. As the average becomes greater than 1.00, it is an indication that the pricing performance of the system is deteriorating. The pricing performance objective of a system would then be to minimize this ratio.

For example, if item one had been purchased 3 times at prices of $1.00, $1.05 and $1.30, and item two purchased 2 times at prices of $2.00 and $2.40 the resulting award ratios of 1.00, 1.05,1.30, 1.00 and 1.20 respectively would be generated. The average award ratio for the system would equal 1.11. This could be interpreted as on the average, each award price exceeded the best price by 11 percent.

Directly related to pricing performance is total cost to award. As the average award ratio of a system increases, the higher the cost of purchasing the items needed. If the average award ratio can be decreased, then cost savings will result.

Manual Review Requirements. An automated procurement system should include some type of pricing review threshold in order to avoid excessive pricing. If a potential award price exceeds this threshold, then typically the purchase is flagged and forwarded to a purchasing agent for manual review. The buying agent would then make a decision to award, resolicit, or cancel the procurement using other information such as price history or urgency. This review increases leadtime and expends employee time. The objective in the automated system (and the embedded algorithms) is then to minimize the number of manual reviews while at the same time maintain reasonable pricing. For purposes of the simulation, the review threshold was set at 15% higher than the best award ratio (best ratio being equal to 1.00).

Resolicitation Requirements. Related to the need for manual reviews are the need to resolicit in the event no bids are received in response to a solicitation. This may be the result of firms out of stock or not carrying the item. This obviously increases the leadtime for purchase (see below). The objective in the system should be to minimize this occurrence by soliciting a sufficient number of firms.

Leadtime to Purchase. Another consideration in an automated EDI procurement system is how long to allow firms to respond before closing the solicitation. The more firms that respond to a solicitation, the better the other performance measurements. Unfortunately, the longer it takes the last firm to respond, the longer the leadtime to procure the item. At some point, the solicitation must be closed and only bids received up to that point considered for award.

Leadtime is also affected by the need to resolicit. If no bid responses are received, then another solicitation has to be issued and more time allowed for firms to respond. Therefore, the leadtime objective is a trade-off between minimizing the time allowed for firms to respond and allowing enough time to obtain a sufficient number of bids from responding firms.

ANALYSIS

Two separate experiments were performed using the simulation model. Both involved modification of the current algorithm for firm selection being used in the EDI procurement system. This algorithm selects the last firm who received an award for the item being purchased plus two other firms randomly selected from eligible firms. Firms are allowed five days to respond before the solicitation is closed. The basis for this algorithm is derived from the Federal Acquisition Regulations (FAR) section (13.1) governing small purchase procedures in the Federal government. In accordance with the FAR, the objectives of the algorithm are to ensure a fair price that is advantageous to the Government considering the administrative cost of making the award, and, at the same time, ensure equitable distribution of contracts among qualified suppliers.

The first experiment involved testing the impact of changing the number of firms selected for solicitation. The last firm receiving an award for the item was still included in this number. This experiment allows testing of theoretical and empirical work discussed earlier in this paper (i.e., as the number of competitors increase, the expected award price decreases). Simulations were run for soliciting a number of firms ranging from 2 to 15 and a final simulation where all 48 firms were solicited.

The second experiment involved a change in the algorithm to include not only the last firm receiving an award, but also the next to last firm. The objective here is to enhance competition by including another firm previously receiving an award. As in the first experiment, simulations were run for various number of firms solicited.

RESULTS

Effects of Number of Firms Solicited. The simulation results showed definite relationships between the number of firms solicited and changes in all the performance measurements. Table 1 on the next page provides a summary of the simulation results. Following is a discussion of these results.

Pricing and Cost to Award. As anticipated by the literature reviewed, increasing the number of firms solicited, thereby increasing the number of competitors, results in decreasing award prices and therefore decreasing cost to award. Figure 1 on the next page depicts this relationship.

As can be seen by Figure 1, overall cost and average award ratio decrease at a decreasing rate as the number of firms solicited increases. For example, the average award ratio decreased by .288 when the number of firms solicited increased from two to four, but only decreased by .151 when the number of firms was further increased to six.

Figure 1 also indicates that significant savings can be obtained in procurement cost in this system as the number of firms solicited increases from two. It is noted that these savings are based on the average monthly workload of the system. Potential annual savings for this system are therefore substantial as the number of firms solicited increases. Annual savings of $5.5 million would be expected if the number of firms solicited increased from two to four; savings of over $8 million would be expected if the number were further increased to six firms solicited.

Manual Review Requirements. As stated previously, the criteria for reviewing a proposed award in the simulation was that the award ratio be at least 15% higher than the best award ratio (1.00). Using this criteria, a substantial amount of manual reviews would be performed at levels where few firms are solicited. Soliciting two firms results in review of almost 50% (1836) of the total awards. If the number of firms solicited were increased to four, 32% (1295) of the total awards solicited would need review. If the number was further increased to six, only 21% would need review; if the number were increased to eight, only 13% would need review. Figure 2 page depicts these results.

TABLE 1
RESULTS OF SIMULATION

NO. SOLICITED	AVG. AWARD RATIO	TOTAL COST (MILLIONS)	NO. RESOLICITED	NO. REVIEWED	AVG. LEADTIME
2	1.599	$2.56	867	1836	4.57
4	1.311	$2.10	195	1295	4.56
6	1.16	$1.86	35	839	4.67
8	1.079	$1.73	12	506	4.81
10	1.046	$1.67	5	312	4.89
12	1.032	$1.65	1	207	4.93
14	1.021	$1.63	0	109	4.96
16	1.000	$1.60	0	0	5.00

Based on 4,000 Simulated Procurements - Avg. Cost $400

FIGURE 1
Effects of Number Solicited

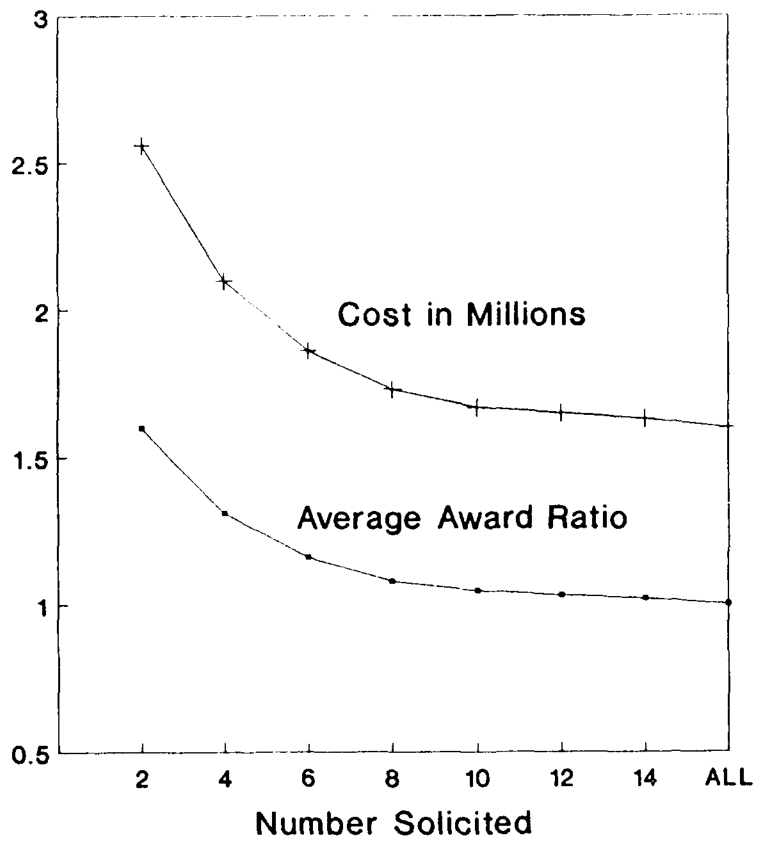
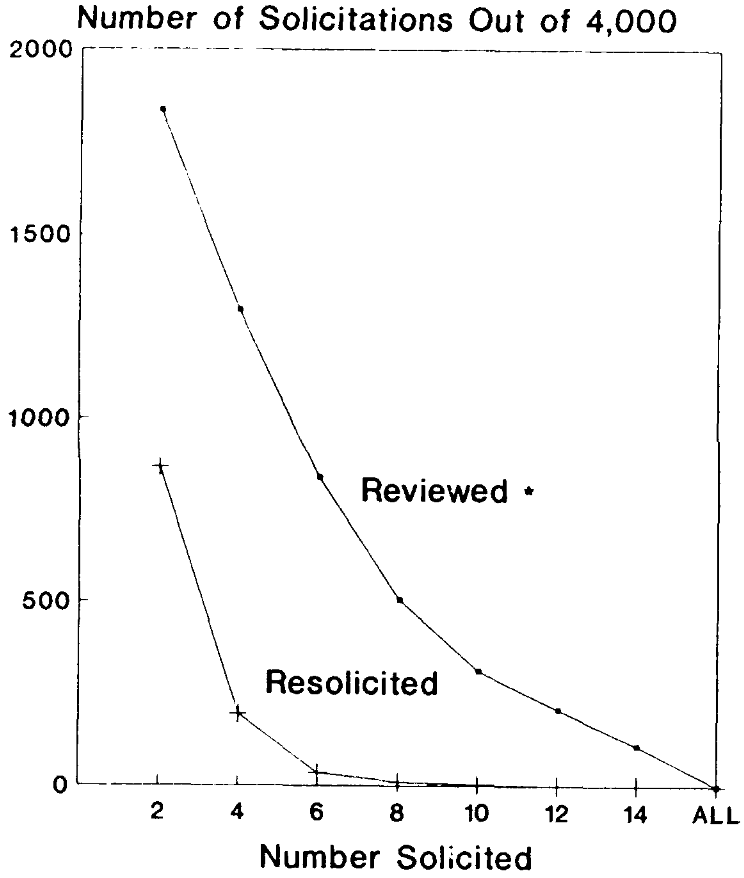
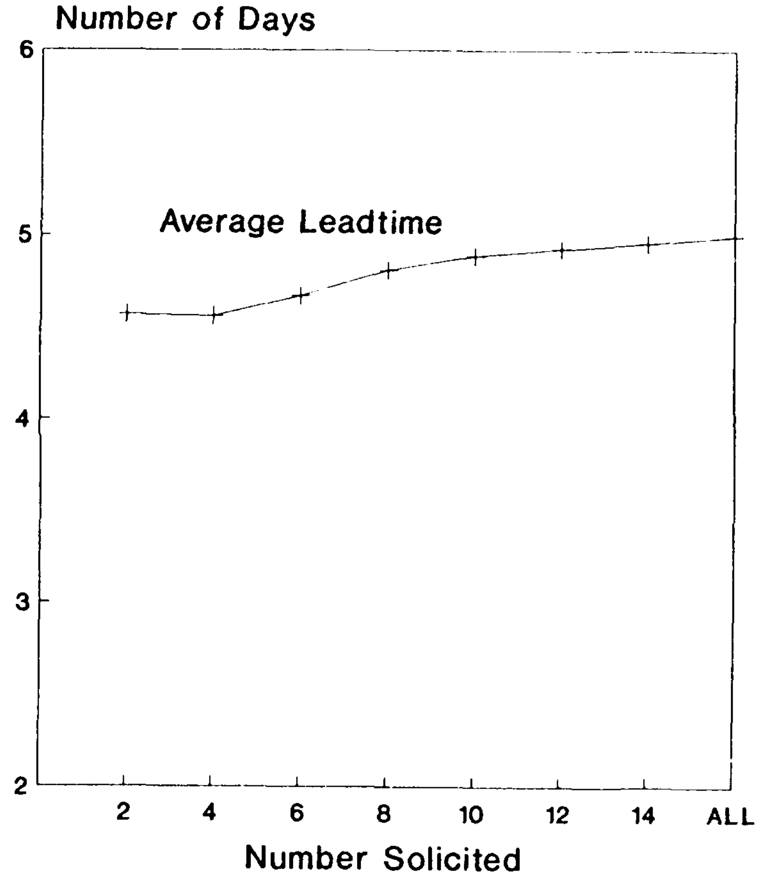


FIGURE 2
Effects of Number Solicited



* Criteria: 15 % Higher Than Best Price

FIGURE 3
Effects of Number Solicited



Resolicitation Requirements. Resolicitation would be required in cases where none of the solicited firms responded with a bid. For purposes of the simulation, resolicitation was allowed one time only. If no responses were received on the resolicitation, the solicitation was cancelled.

The number of resolicitations required decreased dramatically as the number of firm solicited increased from two to six as illustrated in Figure 2. There were 884 resolicitations where two firms were solicited whereas only 63 resolicitations were needed when six firms were solicited. Increasing the number of firms solicited beyond six resulted in minimal reductions in the number of resolicitations required.

It is noted that the need to resolicit due to a lack of responses is directly impacted by the probability of a firm responding to a solicitation. In the procurement system analyzed, there was a 62% chance of a firm responding with a bid. If this percentage was higher, then the number of resolicitations required would be lower across all levels of firms solicited. If there were a 100% chance that each firm would respond, then there would not be any resolicitations issued due to lack of response.

Leadtime to Purchase. It would be expected that average leadtime would increase as more firms are solicited due to the fact that it would be necessary to wait for more firms to respond. Yet the results showed little change in average leadtime as the number of firms solicited increased as depicted in Figure 3 on the previous page.

The average leadtime only increased by .11 days when the number of firms solicited increased from two to six. Soliciting all forty-eight firms used in the simulation resulted in an increased average leadtime of only .40 days over the average leadtime associated with soliciting two firms.

It should be noted that the maximum leadtime that could occur was 5 days. This was due to the restriction in the simulation that a response was due in from a solicited firm within 5 days as currently allowed in the procurement system being modeled.

Soliciting Both Last and Next to Last Firm Awarded.

Simulation results where the next to last firm awarded was included for solicitation (as well as the last firm awarded) showed the same relationships existing between the number of firms solicited and changes in the performance measurements as discussed in previous paragraphs. Soliciting the next to last firm awarded, though, resulted in somewhat better performance for *average award ratio, cost, and manual* review requirements.

Results of these simulation runs are summarized in Table 2 on the next page. Following is a discussion of the significant results.

Average Award Ratio and Cost. The results for average award ratio and total cost ranged from less than 1% to over 3% less than results for similar runs where just the last firm awarded was solicited. After the point where six firms were solicited, though, the measurements showed little or no improvement.

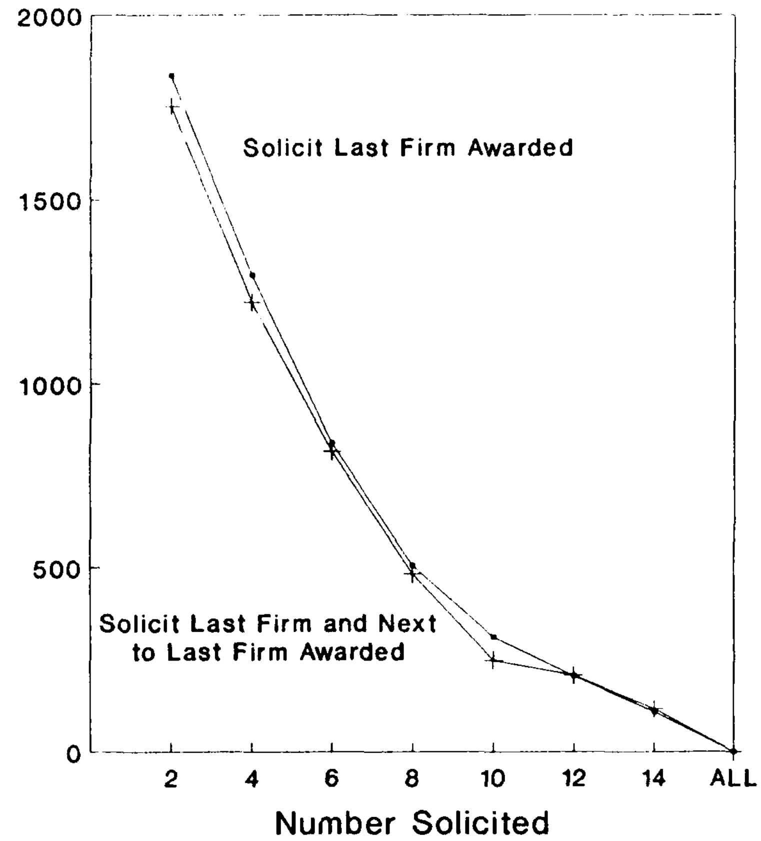
Manual Review Requirements. The need for manual review and resolicitation again decreases significantly as the number of firms solicited increases but even more sharply than when just the last firm awarded was included in the solicitation set. The number of manual reviews ranged from

TABLE 2
RESULTS OF SIMULATION
SOLICIT NEXT TO LAST VENDOR AWARDED

NO. SOLICITED	AVG. AWARD RATIO	TOTAL COST (MILLIONS)	NO. RESOLICITED	NO. REVIEWED	AVG. LEADTIME
2	1.589	$2.54	884	1752	4.60
4	1.306	$2.09	195	1222	4.56
6	1.152	$1.84	63	816	4.71
8	1.08	$1.73	9	483	4.81
10	1.042	$1.67	2	248	4.89
12	1.032	$1.65	0	208	4.93
14	1.019	$1.63	0	117	4.96
16	1.00	$1.60	0	0	5.00

Based on 4,000 Simulated Procurements - Avg. Cost $400

FIGURE 4
Effects of Number Solicited



3% to 20% less than the first simulation runs. Increasing the number of firms solicited beyond twelve showed little or no difference between the two algorithms. These outcomes are depicted in Figure 4 on the previous page.

CONCLUSIONS

Performance of EDI automated procurement systems can be measured using a variety of indicators. Changes in the solicitation algorithms embedded in the system affect performance significantly and should be closely examined to determine if the algorithm will meet management expectation in terms of cost, the need for manual intervention in the system and the leadtime required to make an award.

The results of the simulation analysis presented in this report indicate that the number of firms solicited in an automated procurement system should not be strictly limited. A system should attempt to solicit the greatest number of firms given consideration to the cost of soliciting (e.g., transmission and computer storage cost). In a procurement system where there is a high probability of receiving bid responses from solicited firms, greater consideration should be given to the impact on leadtime when a substantial number of firms are solicited.

The results presented can also be applied to other procurement processes whether they be automated or manual systems. Generally, the more firms solicited, the better the system performs. There is a trade-off though in terms of the cost to solicit and the leadtime required with a higher number of firms solicited.

ENDNOTES

1. See Holt, C.A., "Competitive Bidding for Contracts under Alternative Auction Procedures," Jor. Pol. Econ. 88 (June 1980): 433-45

2. See Kuhlman, J. and S. Johnson, "The Number of Competitors and Bid Prices," Southern Economic Journal 50(1) (1984): 213-220.

3. See Brannman, L., Klein, J., and L. Weiss, "The Price Effects of Increased Competition in Auction Markets," The Review of Economics and Statistics, 69 (Sept 87): 24-32.

4. Refer to the following two articles by Preston McAfee and John McMillan: "Objectives in Government Procurement: Analysis and International Comparisons," special report prepared for the Department of Supply and Services, Ottawa, Canada, January 1986, and "Government Procurement and International Trade: Implications of Auction Theory," unpublished paper, University of Western Ontario, July 1986.

BUDGET and COSTS

COST, QUANTITY, AND INFLATION

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Defense Systems Management College

ABSTRACT

This paper is an abbreviated and simplified version of an internal research contribution at DSMC. The core of the paper belongs in the domain of engineering economy, the peripherals to micro- and macro-economy.

The paper deals with the cost of products in its dependency on production methods, production quantity and inflation. The relationships among method, quantity and inflation are explored in "conceptual form," leading to the development of a "practical tool" for budget planning.

INTRODUCTION

Budgets are variable. Inflation disturbs planning. Programs are stretched-out. Ordering quantities are reduced. This and other events give nightmares to the program manager (PM). But not only to the PM; they give nightmares to any and every planner in the Department of Defense, in industry, and to economists and political leaders up to the highest level. It provides unlimited food for editorials, lunch and dinner speeches, and for most serious concern and national attention. High-level reports have recognized this problem in its fullest and made appropriate recommendations. Optimists hope they will be implemented.

To determine the quantitative impacts of budget changes on cost, due to stretch-out and changes in the ordering quantities is difficult--before the facts. Mostly, Monday-morning quarterback knowledge is used in statistical form for possible forecasts and is of mostly limited value. Others are building sophisticated econometric models of the past in order to extrapolate the results into the future in the hope of creating a credible crystal ball. All those efforts are eminently valuable. They are excellent learning tools and provide intellectual fertilizer to critical thinking. But, the practical results are minuscule.

Could it be, that the quantitative relationship between budget changes and hardware costs, because of stretch-out and changes in the ordering quantities and inflation, are explainable in the simplest terms of engineering economy? Could a return to *fundamentals* provide the answers to those questions? Could it be possible that quantitative answers can be found in fundamentals without search in esoteric regions?

I answer all these questions with a resounding YES. So, let's try to go back to fundamentals and find what the result could be.

PART I
<u>SUMMARY</u>

1. <u>Objective and Scope</u>

A single <u>objective</u> is driving this paper: Explain the cost-quantity relationship for products as applicable to the acquisition of major weapon systems with consideration of inflation.

The <u>scope</u> is restricted to concepts and to a non-mathematical presentation. Graphs are the tools for explanation.

2. <u>Conclusion and Result</u>

It is possible to determine the cost-quantity relationship (with and without inflation) for any and every product, provided the "nominal capital-labor ratio" and the "effective capital-labor ratio" are known. Without this knowledge any prediction remains, at best, an educated guess.

The <u>Nominal Capital/Labor Ratio (NCLR)</u> is the specific ratio in a manufacturing process, which occurs by full facility utilization. Conventionally, full utilization refers to the original planning target for the facility, mostly to an 8-hour shift, provided continuous operation is not a process requirement.

The <u>Effective Capital/Labor Ratio (ECLR)</u> is the ratio that is the basis for a specific contract price at the facility utilization at the specific contract time.

If, and only IF, we know the ECLR for a specific contract will we be able to calculate the NCLR as shown in Fig. 1.

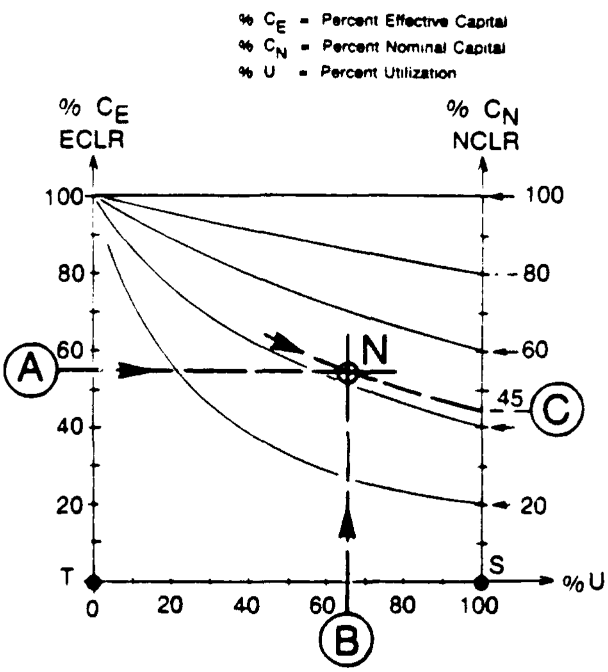


Figure 1. Capital and Utilization

We enter Fig. 1 (the Capital-Utilization Graph) at A and B. Entry A assumes the present contract is based upon an ECLR of 55%, which corresponds for this particular plant to a facility utilization of 65% at entry B. Entries A and B are crossing at point N. Through N, we interpolate graphically toward point C, which indicates an NCLR value of 45%. This means, by full facility utilization, the capital/labor ratio would be 45/55.

With the value of point C, we enter Fig. 2, the Capital-Inflation Graph. The curves are based on the U.S. practice to adjust wages, but not past investments to inflation (or the replacement value). With this graph, we are able to adjust the NCLR value for inflation.

The influence of inflation (or deflation) on the capital/labor ratio has been commonly overlooked, despite its significant influence. The influence is shown in the figure. We enter to Fig. 2 with the C-value of Fig. 1, indicating a capital participation of 45% by a utilization of 100%. Now we assume (as example)

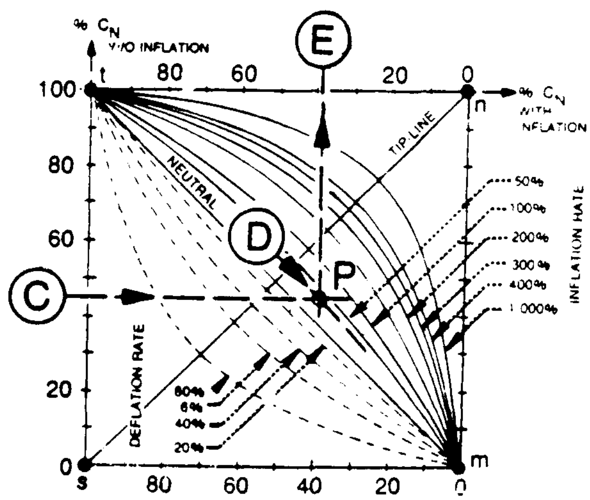


Figure 2. Inflation Adjustment

an inflation rate of 30% -- entry D -- and have the crossing point P. From P we go up to exit E and find out that the NCLR, adjusted for the 30% inflation, shifted from the 45% unadjusted rate to a 39% adjusted rate.

With the exit-value E we now enter Fig. 3 in order to determine the Percent Budget saving for a "ONE" percent quantity reduction.

We cross the entry E with the "optimistic" and "pessimistic" lines at points M and N and move to the left to exits F and G and find, that a ONE percent quantity reduction will result, optimistically, in a 0.39% cost reduction and, pessimistically, in a 0.32% cost reduction. Hence, for example, if the political-economic goal is a 50% budget reduction, the output will have to reduce by (50:0.39 respectively 50:0.32) to approximately 13% to 17% from the present ordering quantity.

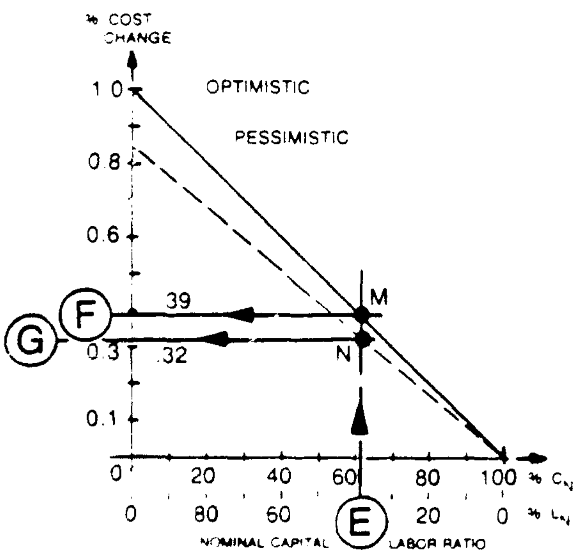


Figure 3. One Percent Quantity Change

In reverse, if we reduce the ordering quantity by 50%, the savings will be (50 x 0.39 respectively 50 x 0.32) approximately 20% to 16% only.

It may be of interest to consider the two extreme conditions. First, the fully automated factory with no workers (point S) and, second, a product that is produced by hand only without any capital participation whatsoever (point T). In the first case at point S, no savings in total cost can be achieved by quantity reduction (i.e., 100 units cost the same as 32 units or 2 units) in the specific value added operation (capital plus labor) and savings might only occur in "material" bought from the outside. (However, if the "outside material" is subject to the same or quite similar capital/labor ratios, even no saving will occur in material). Only in the second case (point T), where the entire process is only labor dependent, will a 1 percent quantity reduction correspond with an approximate 1 percent cost reduction. Reality lies between those two extremes. Nevertheless, we can conclude: THE MORE CAPITAL INTENSIVE A MANUFACTURING PROCESS IS, THE LESS CAN BE SAVED BY QUANTITY REDUCTION. This, of course, is well-known to any manufacturer and every manufacturer will be reluctant to invest in better tools in an unpredictable market situation.

The Fig. 3 diagram gives a guide for <u>reasonable expectation</u> with regard to the quantity-cost-inflation relationship in acquisition operations. The diagram is a planning tool at the highest level for general orientation of "what to expect" from budget changes with or without inflation. It depicts the logic of the cost behavior. The previous figures 1, 2 and 3 are plotted together into a single nomogram as shown in Fig. 4. The nomogram permits us to attack the problem in any desired direction,

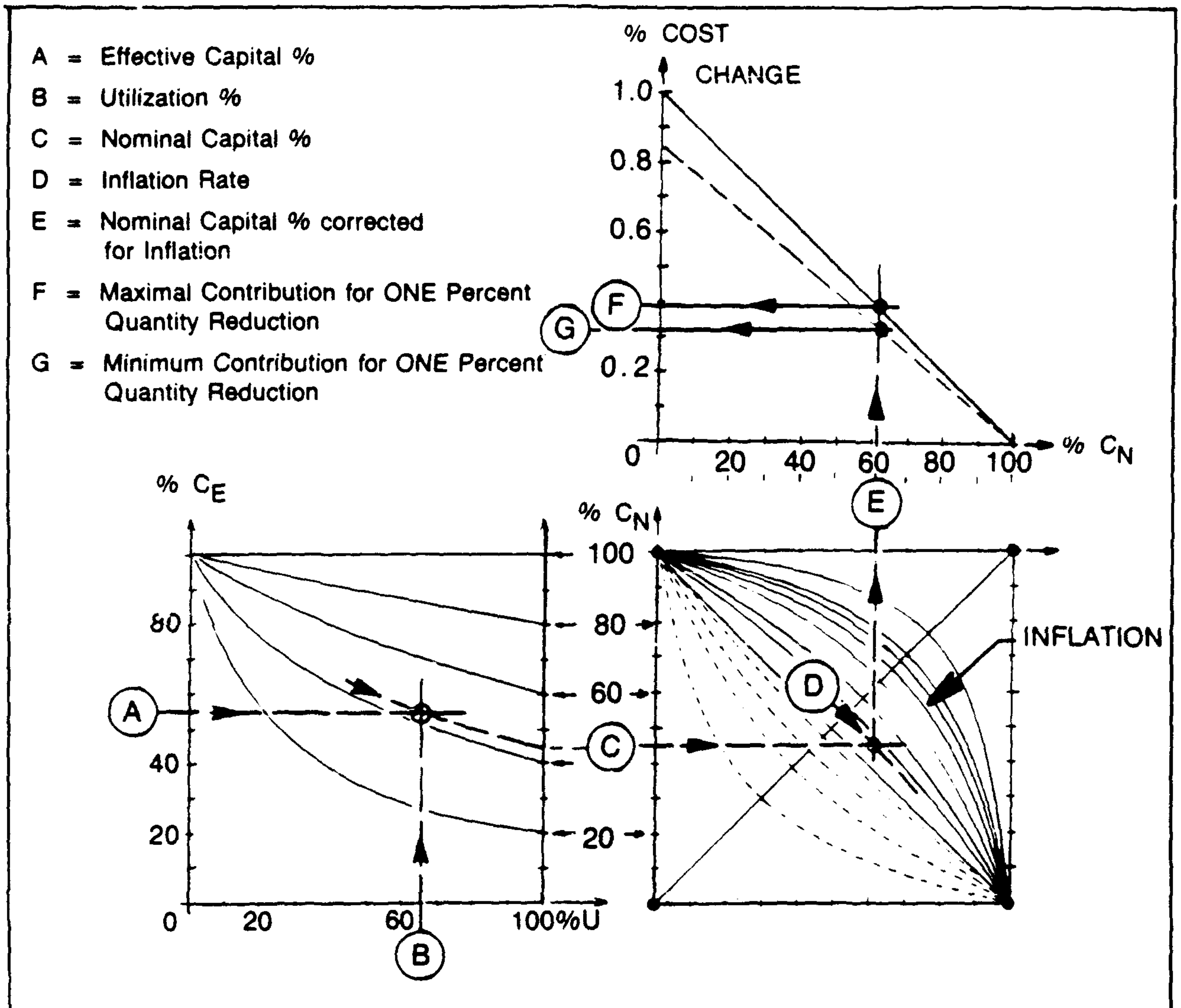


Figure 4. Quantity. Inflation Monogram

since a nomogram is not bound to a specific input-output sequence.

The presented result is supported by the following analytical sketch.

PART II
ANALYTICAL SKETCH

1. Return to Economics-101

Economics-101 is the basic course in economy. There, the relationship between fixed cost and proportional cost is mostly portrayed with a graph (Fig. 5).

The horizontal axis of Fig. 5 represents the numbers of units (N) to be produced, and the vertical axis the cost ($) related to production. The horizontal line through the point "I" in the diagram represents the fixed cost FC(C) because of capital, and the line ascending from point "I" represents the proportional cost PC(L) because of labor and to be added to the fixed cost. Hence, the total cost to produce N_i units will be C_i ($).

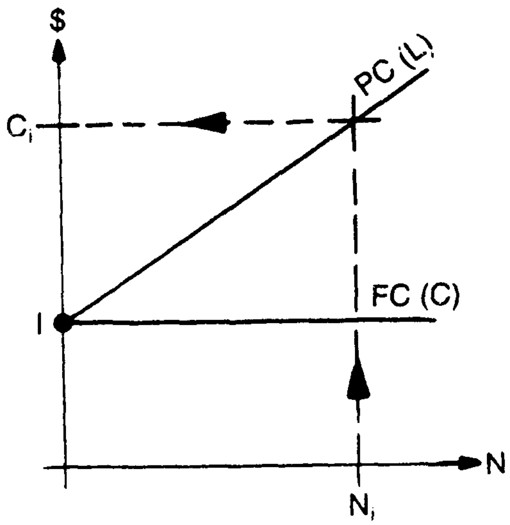


Figure 5. Fixed (FC) and Proportionate Cost (PC)

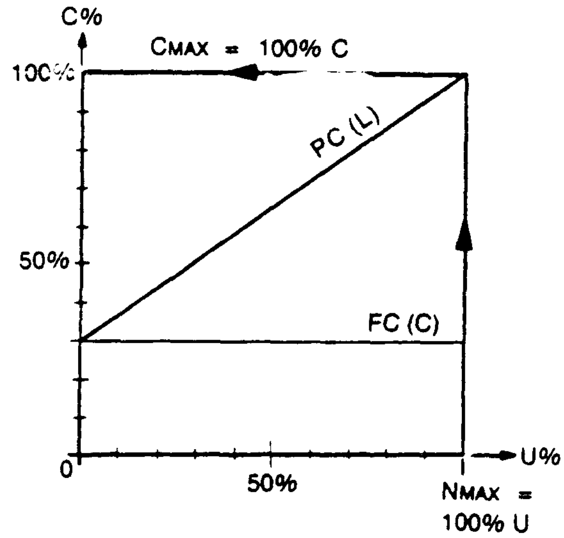


Figure 6. Transition

2. Normalizing the Diagram

The diagram in Fig. 5 has been most specific. Its coordinates are measured in numbers (N) of output and in dollars ($) of cost. In this form, the diagram is able to represent a specific case.

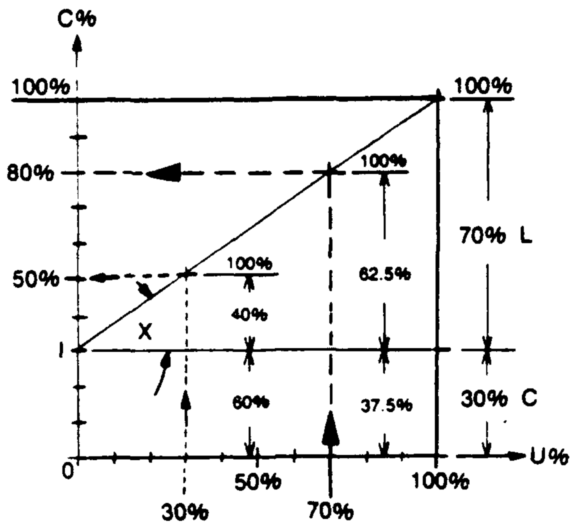
In order to shift from a specific case to a generalization of the quantity-cost behavior, we have to normalize the diagram by taking out the specific dimension and replacing them with dimensionless percentages. This transition from the specific to the general is shown in Fig. 6.

As Fig. 6 shows, we have replaced the N-axis of Fig. 5 with the U%-axis. The "U" indicates the utilization of an investment in facilities and tooling and, logically, the utilization can go from zero-percent to 100 percent (100%-U). The 100%-U value, of course, is identical with the maximal output N_{MAX}, possible with this investment. We also have replaced the $-axis of Fig. 5 with the C%-axis. The "C" indicates the total cost-percentage, related to various degrees of utilization and the 100%-C value, of course, is related to the 100%-U value.

With this, we have changed the specific diagram of Fig. 5 into an all purpose diagram, depicting the "C%-U%" relationship, as explained in Fig. 7.

Fig. 7 represents the normalized diagram and (as an example) a 70% labor participation (70%L) and a 30% capital participation (30%C) at 100% utilization. This means, in the example, a capital/labor ratio of 30/70 exists at full capital utilization. This, in turn, defines the "angle X" as the representative of a preselected production method.

First, expressed in monetary terms, this is a statement of "local truth," to be used with care. It assumes a constant labor rate and constant capital cost; it restricts comparisons to areas of valid



UTILIZATION	30%	70%	100%
NOMINAL CLR	-	-	30/70
EFFECTIVE CLR	60/40	37.5/62.5	(30/70)
PROGRESSIVE COST	50%	80%	100%
CAPITAL COST INDEX	30	30	30
LABOR COST INDEX	20	50	70

Figure 7. Normalized Diagram

comparability; it is valid, for example, for all manufacturers in the United States or to all in India at a specific time. But, it does not permit a one-to-one mapping between the United States and India or between different time frames. Second, expressed in physical terms, the statement is "absolute truth." For example, machine A needs 2 workers for its operation and machine B needs 5 workers. In the first case, the physical machine-labor ratio is 1:2 and in the second case is 1:5, regardless if this process is performed in the United States or in India. The physical effort of machines A and B and of the workers could be expressed in calories, resulting in an unconditional, valid description and comparison of the processes associated with machines A and B.

The angle "X" is invariable over the entire range of utilization; however, the labor/capital ratio is NOT invariable over this range. This ratio changes with the utilization and permits on each point the "internal" normalization of the operation as shown for the 70% and the 30% utilization: Case (a) at 70% utilization, the total cost % is reduced to 80%, subdivided into 50% for labor and 30% for capital. Now we define the 80%-C as 100%-C for the 70% utilization and find that the labor/capital ratio at 70% utilization has shifted to a 62.5/37.5 ratio (as compared with a 70/30 ratio for full utilization). Case (b) at 30% utilization (or output), the total costs are reduced only to 50% and again, after internal normalization, the labor/capital ratio has changed to 40/60 versus the 70/30 ratio for full utilization. This means the "labor-intensive" operation at full utilization has changed to a "capital-intensive" operation at 30% utilization. These changes for cases (a) and (b) are summarized in Table-I in the form of a sample calculation.

Table-I shows eight horizontal entries crossing three percentage of utilization, starting with 100% utilization, followed by a 70% and a 30% capacity utilization. Line-1 shows the capital/labor ratio at different utilization percentages. Line-2 repeats (for calculation purposes) the output percent in order to underscore that the output percent must be identical to the utilization percent. Line-3 normalizes internally the output to "100% by definition" for the different percentages of utilization. Line-4 indicates the percentage of total cost for the three selected utilization ratios and outputs. Line-5 gives the unit cost at the different utilization rates and, as to be expected, the UNIT COST GOES UP WITH THE DECREASE IN UTILIZATION.

The calculations shown in the next three lines are slightly obnoxious: They are correct but disturbing to conventional economic dogmatists.

Table I. Sample Calculation

	UTILIZATION 100%	70%	30%
1. CAPITAL/LABOR RATIO AT % UTILIZATION	30/70	37.5/62.5	60/40
2. OUTPUT % AT % UTILIZATION	100%	70%	30%
3. NORMALIZED OUTPUT BY DEFINITION	100%	100%	100%
4. TOTAL COST OF OUTPUT AT UTILIZATION %	100%	80%	50%
5. UNIT COST AT UTILIZATION %	100/100 = 1.0	80/70 = 1.14	50/30 = 1.67
6. LABOR EFFICIENCY NORMALIZED OUTPUT/WORKER	100/70 = 1.43	100/62.5 = 1.60	100/40 = 2.50
7. CAPITAL EFFICIENCY NORMALIZED OUTPUT/CAPITAL	100/30 = 3.3	100/37.5 = 2.7	100/60 = 1.7
8. PLANT EFFECTIVENESS OUTPUT (2.)/TOTAL COST (4)	100/100 = 1.0	70/80 = 0.9	30/50 = 0.6

Line-6 gives the labor efficiency expressed as output per worker and, lo and behold, THE LABOR EFFICIENCY INCREASES WITH DECREASING UTILIZATION from 1.43 for full utilization up to 2.50 with 30% utilization. This means labor efficiency is reciprocal proportional to utilization and any meaningful definition thereof can NOT be provided without the knowledge of the degree of utilization. Line-7 shows the capital efficiency and, of course, THE CAPITAL EFFICIENCY DECREASES WITH DECREASING UTILIZATION from 3.3 down to a 1.7 value. Line-8 finally shows the total plant effectiveness starting with 1.0 for full utilization down to 0.6 with a 30% utilization as not otherwise expected.

3. Pattern of Cost Behavior

"Cost" in industrial operation has an inherent logic as dictated by:

(a) the selected production method as given by the method-angle X (see Fig. 7) and

(b) by the factor-utilization expressed in U% (see Fig. 6 and 7).

"Price" for industrial products is an entirely different story and will not be discussed further. I only call to your attention that major military acquisition are dealing with "cost" and not necessarily with "prices," disregarding that prices enter the lower tiers of the acquisition as a function of market behavior and of exchange rates as far as foreign sources are concerned.

The inherent logic of cost permits us to identify two cost areas:

- First, the area of the total program cost and
- Second, the area of the unit-cost

These two areas are shown in Fig. 8.

Figure 8 has a total of three scales. First is the horizontal axis, called the utilization factor, running from 0% to 100%. Second is the right vertical axis indicating the total program cost, going from 0% up to 100%. Third is the left vertical axis going from zero index up to an index value of 10. The first area (indicated in Fig. 8) between the points A, B and C is the program cost area between the two dotted lines. The upper horizontal dotted line represents a production method that utilizes 100% capital and 0% labor. You might identify this as the workerless computer-driven factory. A PROCESS BASED ON 100% CAPITAL WILL COST THE SAME, REGARDLESS IF IT IS FULLY UTILIZED OR NOT. Expressed in a more pedestrian form: The owner of the fully automated workerless factory has to pay to his bank monthly installments, regardless if the factory works at full capacity, below full capacity or not at all.

The dotted line, running diagonally from the left lower (point A) corner to the right upper corner (point B) represents a production method that utilizes 0% capital and 100% labor. The closest example to the extreme case with 100% labor and 0% capital would be the old factory, where all equipment, buildings and other investments are already many times over-depreciated down to a zero book value. For this case, the total value-added cost of the operation is directly proportional to the percent utilization or to the factor utilization. Again, most pedestrian-expressed, the owner of this scrapyard hires and fires people according to work, but he does not make any payment to his bank.

In between these two extremes, all program costs MUST be located. No program cost can exist outside of this range.

<u>The second area</u> (indicated in Fig. 8) between the points D, E and F is the

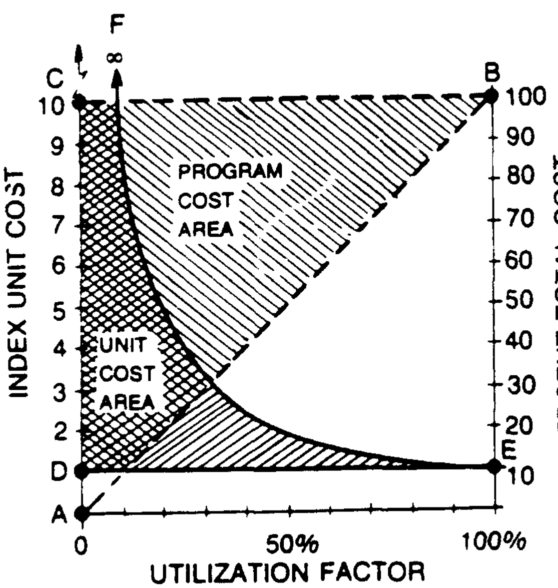


Figure 8. Range of Cost

<u>unit-cost area</u> between the two full lines. The upper line, dropping from the top on the left side (point F at infinity) to the bottom on the right side, represents the unit cost curve for the fully automated factory, where only capital (100%-C) enters as a factor of production and the unit cost will be "1" only at 100% factor utilization, while at 10% factor utilization the unit cost will be "10." Not so for the other extremes, where only labor (100%-L) is considered as factor of production. In this case, of course, the unit-cost curve is horizontal and constant "1."

Filling in the two areas of possible cost behaviors leads to two normalized cost nomograms: one for the unit cost (Fig. 9) and one for the total program cost (Fig. 10).

In Figure 9 the unit-cost curves are plotted for 0% C, 20% C, 40% C, 60% C, 80% C, and 100% capital as factor of production. The point of importance is, that between about 80% and 100% utilization, the difference in the unit cost might be negligible in its dependency about the capital factor. However, moving to the left, the capital factor of production increases in importance. This means, the SENSITIVITY of unit costs to under-utilization increases with the increase of the capital factor.

Figure 9 shows the total program cost curves for 0% C, 20% C, 40% C, 60% C, 80% C and 100% capital as factors of production. One example illustrates the chart: If, for example, a production method by 100% utilization is based upon a capital factor of 46% (entry "1") and the facility is only utilized with 52% (entry "2"), then the cost of this 52% output will

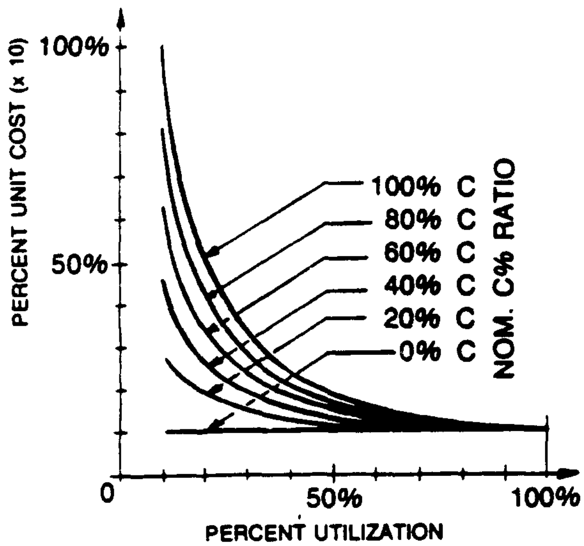


Figure 9. Unit Cost

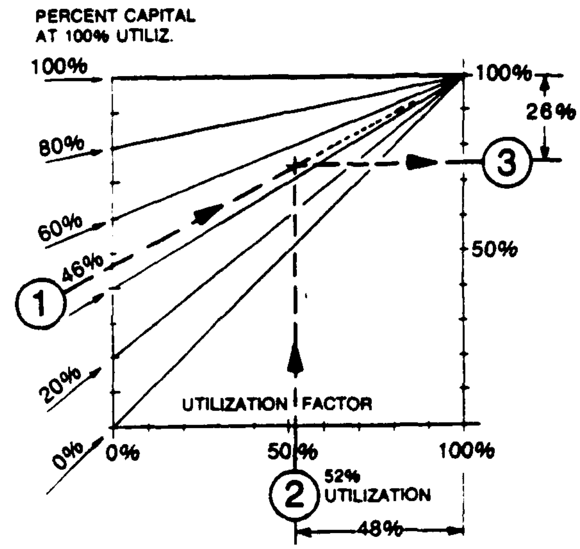


FIGURE 10. Program Cost

result in a total program cost reduction down to 74%. Differently expressed, a 48% program reduction (or facility utilization) will result only in a 26% cost reduction. This means, the Delta in quantity reduction is different from the Delta of cost reduction, and the Delta of cost is a function of the capital/labor ratio or the process angle (X) of the specific operation.

This relationship is plotted in Figure 11.

The horizontal axis in Fig. 11 represents the capital/labor ratio <u>at 100% facility utilization</u>. The horizontal scale goes from 0% capital (the purely manual operation) to 100% capital (the workerless factory). The complementary scale for labor starts at the right side with 0% labor and goes to the left with 100% labor as factor of production. Hence, every point on the horizontal scale represents a specific method of production expressed with its C/L ratio for Nominal Capital Allocation at zero-time or the beginning of a contract.

The vertical axis represent the process cost change for "<u>ONE PERCENT</u>" of quantity change.

The <u>example</u> illustrates the chart:

- <u>Assume</u>, we have a production method that is characterized at full utilization with a capital/labor ratio of 65/35 at contract time. Enter (in Fig. 11) vertical arrow (E) and cross heavy diagonal line at point M.
- <u>Question</u>: If we reduce the production rate by ONE percent, how much will the program cost be reduced?
  <u>Answer</u>: Plot a horizontal line through point M and cross the vertical axis at point N toward exit (F). Reading

the value for N, the diagram informs you, that ONE percent change in the production rate will result in a 0.35% reduction in program cost.

- Therefore, if you reduce (for budgetary reasons) the production rate, let's say by 20%, then the expected program cost reduction will be 20 times 0.35 or 7%.
- In reverse, therefore, if you wish to increase the production rate by, for example 10%, the total program cost should not increase more than 10 times 0.35 or by 3.5% (provided you produce from the outset at or below a 90% utilization).

The line A to B presents the best possible relationship between budget change and product cost. It can only get worse --but never better.

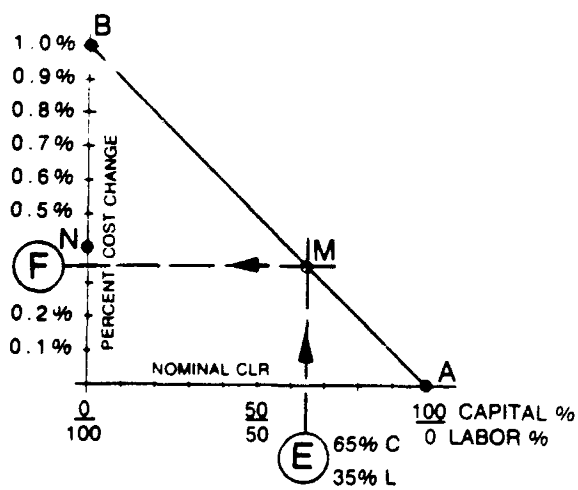


Figure 11. Cost Change for One Percent Change in Utilization

4. Capital Allocation and Utilization

Two types of capital allocation exist:

- First, the NOMINAL CAPITAL ALLOCATION (C_n)
- Second, the EFFECTIVE CAPITAL ALLOCATION (C_a).

Both capital allocations are related to the UTILIZATION (U%) of the facilities under considerations.

The Nominal Capital Allocation (C_n) is related to the 100% utilization of the facilities and the Effective Capital Allocation (C_e) is related to the facility-utilization at the contract-point. This means any price quoted by a contractor at any specific time MUST be calculated upon an assumed facility-utilization and its related cost at the time of the contract.

The relationship among C_n, C_e and U% has been plotted in the previous Figure 1 in simplified form.

5. Inflation

The foregoing sections are based upon the assumption of a stable economy, free of inflation. Now we eliminate this simplifying assumption and try to count for the impact of inflation.

Assume a single-product factory already is producing for 2 years a specific military product and the production rate was constant during this period. Now we are entering the third year of production and, for budgetary reasons, the production rate shall be reduced and, hence, the percent of utilization of the respective facility. Furthermore, we assume to be in a significant inflation environment. How will the change in production rate, plus the inflation, impact on program cost? (For reasons of simplicity, we ignore how the manufacturer has coped with the previous inflation). This shall be discussed.

Reviewing the last 20 years of the U.S. economy, we will notice that the enumerations (wages and salaries) of active workers are, generally speaking, indexed. This means wages follow the cost-of-living index as published by the government. Capital investments are not indexed to the sorrow of all lenders and the joy of all borrowers. This means, for a given production method, the numerical part of the labor cost will increase, while the capital part remains constant. With this, however, the capital/labor ratio changed with inflation, as illustrated in Table II.

		BEFORE INFLATION	AFTER INFLATION
	IN DOLLARS:		
1.	CAPITAL $	70	70
2.	LABOR $	30	160 1/
3.	TOTAL $	100	230 2/
	IN PERCENT:		
4.	CAPITAL %	70	30
5.	LABOR %	30	70
6	TOTAL %	100	100
7.	CAPIT./LABOR RATIO	70/30	30/70

1/ General inflation approx. 430%

2/ Specific product inflation approx. 130%

Table II. Capital/Labor Ratio

Before and After Inflation

The selected numerical inflation values in Table II are in the U.S. economy unheard of...however, the figures are selected not as a doomsday forecast but for illustration only.

Lines 1, 2 and 3 show the dollar values for and after the inflation for the specific manufacturing process. Neither the number of workers has changed, nor has the tooling for the operation. From a physical point of view, the operation including utilization or production rate is exactly the same before and after inflation.

Line 1 shows the capital cost as $70 before and after inflation. The company may have bought the equipment with a loan with fixed interest rates and the monthly payments have not changed because of inflation. Replacement costs are not considered.

Line 2 shows the labor cost: Before the inflation $30 and after the inflation with $160. This would represent a <u>general inflation index</u> of 430%. Line 3 shows the total cost of the operation before and after the inflation with $100 and $230, respectively. This means the <u>specific inflation</u>, or the cost increase because of the general inflation and indexed wages, is only 130%. It is important to note that GENERAL INFLATION AND SPECIFIC INFLATION MOSTLY ARE <u>NOT</u> THE SAME.

Lines 4, 5 and 6 translate the numerical values of lines 1, 2 and 3 into percentages and line 7 shows that, after this normalization, the capital-labor ratio of initially 70/30 has been <u>reversed</u> to 30/70. This means the capital intensive operation, before the inflation, has changed into a labor intensive operation after the inflation. The ratios have exactly reversed.

Table II is the calculation for a single example; the extension toward the entire spectrum of the capital-labor ratio has been shown in a simplified version in the previous Figure 2.

7. Validity of Concept

Every forecast is burdened with uncertainties about the future, and every generalized concept with exceptions and possible variations. The sum of uncertainties and exceptions leads to the question about the validity of the concept as outlined in the foregoing sections.

Exchange rates among the U.S. dollar and other currencies are not considered in the concept. The impact of changes in the exchange rate will depend upon the domestic and foreign content of a product. My last paper at the 1989 Acquisition Research Symposium dealt with this subject most specifically.[1]

Cost remanence and cost hysteresys are another neglected aspect. Both terms are borrowed from the European literature[2] and describe the "up and down of cost" as function of facility utilization. Figure 12 illustrates this uneven behavior.

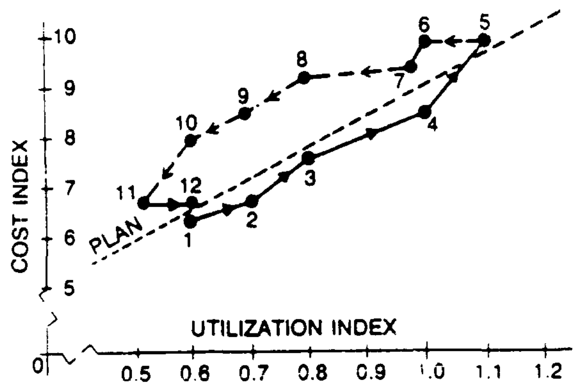
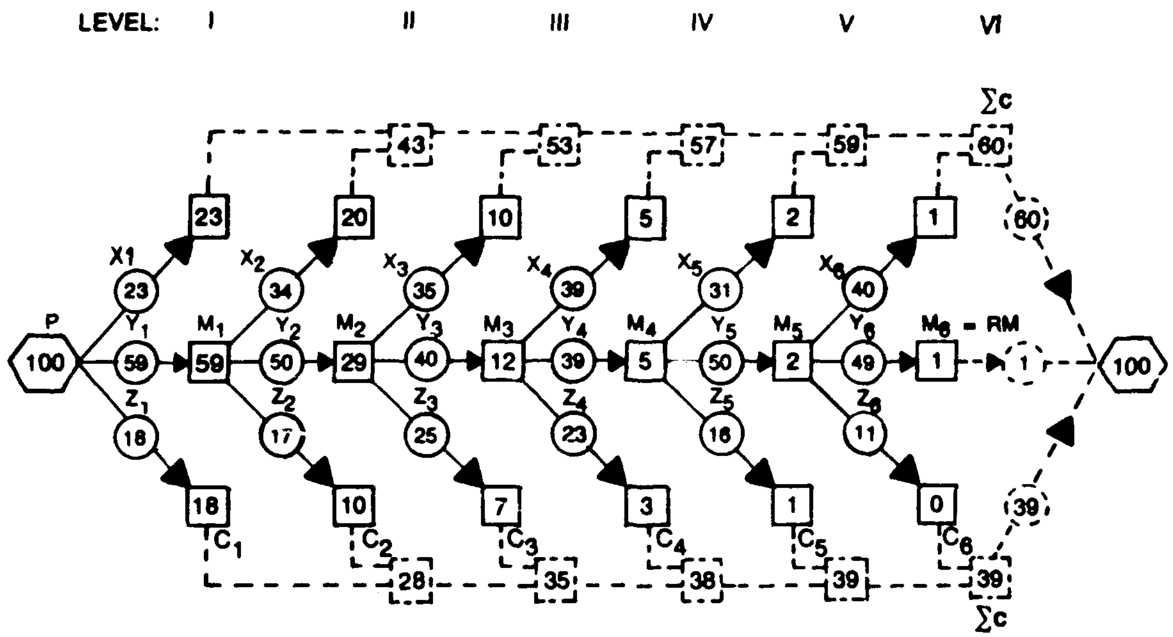


Figure 12. Cost Remanence & Hysteresis

The horizontal axis in Fig. 12 shows the degree of utilization of a facility and the vertical axis the cost level on a scale from zero to ten. By increasing workload from point "1" to point "5," the cost increase follows approximately the plan as indicated with the dotted line. If the workload (as utilization) decreases from point "5" to point "11," the cost-return-run will be above the planning-line. Some cost remains in the system; hence, the term remanence and only a renewed utilization increase from point "11" to point "12" will close the loop, resembling a hysteresys curve.

Structural variations are the third element entering the validity consideration. Structural variations are expressed with the "L-M-C concept," where L stands for labor, M for material and C for capital.[3] The concept is shown in Fig. 13. The sample in Figure 13 uses figures for an American passenger car of approximately 1978 and subdivides the L-M-C structure into six levels: (1) level-I, the system; (2) level-II, the subsystems; (3) level-III, the components; (4) level-IV, the parts; (5) level-V, the materials and; (6) level-VI, the raw materials.

Figure 13 starts on the left side with the end produce (P) (the car), identified as 100%. This product is subdivided into X_1%, Y_1% and Z_1%; in numerical values into 23%, 59% and 18%, respectively. This leads at level-I to a L-M-C allocation of 23, 59 and 18 units. The material (M_1) of the first level is again subdivided into 34% (X_2), 50% (Y_2) and 17% (Z_2), leading at the level-II to an allocation of 20, 29 and 10



ORIGINAL COST BREAKDOWN		CHANGES BECAUSE OF THE STRUCTURE	TOTAL PROCESS COST BREAKDOWN
LABOR	23%	.....LABOR % **INCREASE** FROM 23% TO 60%....LABOR	60%
MATERIAL	59%	.....MATERIAL % **INCREASE** FROM 58% to 1%....MATERIAL	1%
CAPITAL	18%	.....CAPITAL % **INCREASE FROM** 18% to 39%....CAPITAL	39%
TOTAL	100%	.....REMAINS **UNCHANGED**................................ TOTAL	100%

Figure 13. Single Line Linkage - Car Example

units. Continuing this method of L-M-C decomposition through all six levels gives us, at each individual level, the labor, material and capital allocation. We notice that the absolute value of material decreases continuously, while the labor and capital allocation behaves additively toward the right side, where all intermediate materials are dissolved into the value-added portion; in the end, all that remains is only ONE% for the raw material on the right side of the figure and 99% describe the total value added through the entire process.

It appears that the errors by "considering the prime contractor only" and by neglecting the value-added variations (labor plus capital) in the lower tiers might be of little significance. The error as result of this is shown in Fig. 14.

In order to be on the safe side, a range-line for errors is suggested. In the summary graph (the previous Fig. 3) the range-lines are called "optimistic" and the "pessimistic" behavior.

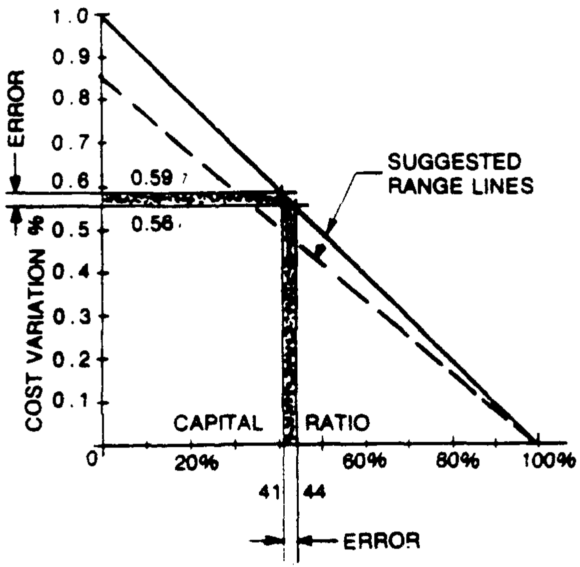


Figure 14. Validity Range

7. Final Remarks

The present paper gives a guide for rational expectations of how product costs may change as result of budget changes and inflation.

To translate this rational expectations into ironclad predictions would require some regulatory requirement and additional research. The regulatory requirement would be the inclusion of the capital-labor relationship of a contract and of the disclosure of the utilization rate as used as basis for the contract cost. However, in order to respond to such requirement, a large amount of research would be the prerequisite: We have no standards for measuring utilization; we know very little about the L-M-C structure for different products at all product levels; we have no uniform product taxonomy beyond the statistical listing of industrial activities; etc. etc. etc. All those research activities are expensive. Are refinements really necessary? This, of course, is not for me to answer. All I want to do is to demonstrate the existence of an undisputable logic about the interrelationship between cost, quantity and inflation.

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COST ESTIMATING STUDIES IN SUPPORT OF ARMY AVIATION

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ABSTRACT

In the military-defined environment, the efforts to advance the state-of-the art technologies for helicopter systems continue to accelerate, increasing ambiguity and uncertainty of the costing environment. Army Aviation's Cost Analysis community serves management by providing services directed to cost estimates to assist in the decisionmaking process and analysis of cost estimates prepared by other functional elements. Emphasis is placed on the project life cycle which impacts the materiel acquisition process. Aviation research and development programs have high risks in schedule, technology and cost methodologies. Operational programs, i.e., aircraft deployed, have less uncertainty but strong needs for estimating the funding for logistical support. The overall challenge is: We are faced with a dichotomy as we feel high technology is the key to maintaining the qualitative edge. Yet, we find our attempts to use all our technology positions us where we may outstrip our cost analysis support capacity. In the name of performance, we have introduced a degree of complexity and risk that we have difficulty in systematically costing, managing and controlling.

The commitment of the cost analyst is to assist the decisionmaker by providing what he needs to know, especially insights into hard, previously unaddressed cost implications and provide this in time for him to use it. Cost analysts must communicate clearly what study results are, what we think are the cost strengths and limitations. If we do all this, we succeed in making cost estimating a continuing and important aid in decisions.

Specifically, the cost community is looking at the following:

a. develop a broader range of products.

b. staff organizations with highly competent people.

c. improve cost studies/reports to provide accurate and timely information.

d. demonstrate ability to anticipate changes.

To best respond to the acceleration of technology, systematic use of the five basic steps of cost estimating is still effective: (1) understand the problem and divide it into its elements; (2) gather data upon which to base the estimate; (3) develop cost estimating relationships; (4) proper use of the estimating relationship; (5) present the result. The need remains for expanded knowledge and analytical skills and for coping with perennial problems of analyses associated with acquisition and logistical support of Army helicopters.

INTRODUCTION

The process by which Army aircraft systems are developed, tested, and procured has evolved into a highly sophisticated series of interactions among agencies responsible for establishing requirements, carrying out developments, and evaluation of the resultant weapon systems. Army cost estimators must constantly meet the strongest criteria for accuracy, realism, and substantiation.

Let me acquaint you with some of the environmental setting(s) in which my organization works. The U.S. Army Aviations Systems Command (AVSCOM) is an acquisition activity and has an authorized manpower level of over 5600, including labs and other activities, and an annual operating budget of approximately $5 Billion. Now, just what are its purposes, functions, and responsibilities? Briefly, the purpose of our Command is:

PURPOSE: To conduct and manage the logistical support, research and development and acquisition of U.S. Army Aviation Aircraft Systems for use by Army personnel for both combat and non-combat missions.

FUNCTIONALLY: Plans, directs and supervises the design, development and major modifications of aircraft systems and subsystems and provides full technical and administrative support to project management offices.

AERONAUTICAL MATERIEL: Includes both fixed and rotary wing aircraft, ground support devices, ancillary equipment and airborne communication systems.

My part as the Director of Systems and Cost Analysis with approximately 70 personnel, who with the exception of the administrative staff are all ORAs, is to manage the Command's Operations Research/Systems Analysis (ORSA) assets with a primary concentration of cost estimating effort toward the acquisition and logistical support of military helicopters. Our major aircraft category capabilities are: attack, reconnaissance, lift, cargo, intelligence and electronic warfare, and special operations aviation.

In researching the selected topic, it was almost overwhelming to list some of the negative impacts of our working environment--such things as budget reductions, the fast developing of high technologies, the scarcity of available skills necessary to respond to cost estimating tasks involving sophisticated hardware--the impacts of these important items are undeniable, and they will be surfacing as a common thread throughout the presentation. In pulling together pertinent criteria to measure the cost estimating studies trend, we will make a survey of our working environment, both macro and micro, and the impact(s) of such in our world of estimating costs of military hardware and on the taskers that require these studies.

In the ever present hostile threat environment, the efforts to advance the state-of-the-art technologies for helicopter systems continue to accelerate, increasing the ambiguity and uncertainty of the cost estimating environment. The Cost Estimator serves as a consultant to management through the providing of services directed to cost estimates to assist in the decisionmaking process and analysis of cost estimates prepared by others, such as potential contractors and consultants. Emphasis is placed on all phases of the project life cycle which impact on the materiel acquisition process.

Cost estimating techniques used by the Government and the helicopter industry in the concept development and acquisition process have evolved over a number of years, always with increasing demands for more credibility, capability, and knowledge requirements on the part of the analyst. There is, as always, the constant demand(s) for quality studies and for comprehension of and rapid reaction to the new technologies and new concepts. Such demand(s) dictate the critical role of the challenge to define, develop, and apply new techniques.

We know that Cost Estimators are deep in a fast-changing world of new concepts and high technology and assigned tasks are undergoing an irreversible and often turbulent change. While change has always been a part of experience, its scope and velocity are much greater than at any time in the past, making analytical versatility a prerequisite for keeping pace in this environment. To respond to this challenge of the acceleration of technology, we need to be aware and recognize the needs of the type of tasks being assigned and what we in the business of the acquisition and support of Army helicopters must do to respond and best cope with these trends.

Cost estimating is an admittedly uncertain endeavor. The reasons for the uncertainty associated with cost estimating are many and varied. Our purpose is to present a means of first quantifying cost uncertainty and, second, calculating the amount of additional funding, or risk capital, necessary above and beyond the total estimated cost to give an acceptable probability that there will not be a cost overrun.

CONCEPTUAL FOUNDATIONS

Cost analysis in the DOD is an integral part of the planning, programming, and budget processes in materiel/nonmateriel system and force structure cost estimating and analysis. Cost analysis includes cost estimating of systems and programs throughout their life cycles, maintenance of cost estimates through update and revision, independent validation of cost estimates, and provisions for tracing cost estimate via data base management and documentation of cost estimating methodologies.

Cost estimating and analysis is required at all levels throughout planning, programming, budgeting, and execution, to ensure that the overall cost of materiel systems, force units, and activities is credible and realistic; and costs are presented in ways which promote the best allocation and management of Army resources. To that end, cost analysis serves as a critical function in all resource processes, including planning, programming and program execution, system acquisition, budgeting and budget execution, source selection, and contract preparation and negotiation, among others.

In order to perform the functions of cost analysis, both a multidisciplined, technical approach and a broad-gauged, mission-oriented approach are required. On one hand, cost analysis employs a variety of operations research, engineering, economic analysis, and data management techniques. At the same time, cost analysis requires a broad understanding of complex economic issues, military operations, and management objectives. The combination of such skills is prerequisite to the proper functioning of cost analysis as a major contributor to the resource management process.

Clear Identification of Task. To prepare a cost estimate, the estimator must have the description, ground rules and assumptions, and technical and performance characteristics of the system. A well-defined system description which specifies conditions and constraints of the estimate is essential to clearly identify the scope of the estimate and document how it was prepared.

Broad Participation in Preparing Estimates. Acquiring a major weapon system involves both Government and contractor organizations in deciding mission needs and requirements and defining performance parameters, force structures, and other system characteristics. The cost estimate should ensure that all organizations with input into the system design have participated in preparing the cost estimate. Each organization should have had its data independently verified for accuracy and completeness and should have guidelines for cost controls in place to ensure the reliability of its data.

Availability of Valid Data. Numerous data sources that vary in reliability are available to the cost estimator. Highly significant is that a great deal of "soft" data is the principal source of the historical data base from which the cost estimators project costs of new systems from previously comparable systems. The estimator learns to use care in determining if such data are suitable for the purposes intended. Ideally, the data should reflect current cost trends and be directly related to the system's performance characteristics and specifications.

The Cost Estimator is concerned with making rigorous analyses which assist in the management decisionmaking process, must deal with imprecise data, and provide for risks and uncertainty. In addition to application of advanced scientific and analytical methods, he is concerned with completeness and consistency in terms of definitions, format, and cost elements, as well as the final estimate.

It is important to note that cost estimating tasks to support development projects and those required to support logistical support projects are somewhat different.

The Project Manager of an Army aircraft in development has the requirement to definitize hardware configuration to meet the "user" requirements. This requires studies comparing the costing of alternative hardware configurations and studies exploring the alternatives for balancing hardware capability against costs. Aviation developmental programs have high program risks in schedule, technology, and cost methodologies that support project management planning. Judgments of cost of work performed are made in the face of many uncertainties and risks inherent in programs that span many years, particularly those that embody new technology; a formal decision risk analysis is a requirement for these programs. Information regarding studies of a typical developmental program is presented.

Project Managers of Army aircraft in the production and operational phases are faced with fixed hardware configurations and have little flexibility in this area. Instead, they are concerned with the costs of supporting fielded hardware. Operational aircraft programs have much less uncertainty but have strong needs for estimating the funding necessary for logistical support. Information regarding tasking for studies involving currently operational aircraft is presented.

Army Aviation's cost estimators are directed to three major functional thrusts: Cost Estimating, Review and Validation, and Research and Methodology. These functional thrusts are in turn focused to estimating and analysis as follows:

Cost Estimating. In support of Baseline Cost Estimates, in support of cost-effectiveness studies, system analysis efforts, and trade-off determination, in preparation of Independent Cost Estimates (ICEs) for major weapon systems, in preparation of estimates for non-major weapon and equipment systems and in support of Economic Analysis efforts for both investment and materiel program decisions.

Analysis & Validation. To provide a system of checks and balances over a wide range of related cost oriented management documents, to provide objective and independent analysis of cost issues, and to provide consistency and completeness of estimates prepared by other functional activities.

Realistically, when tasked to develop the cost estimate(s) for an aircraft system (developmental or operational), the estimator faces a challenge in locating valid data. The type and quantity of data required by modern analytical techniques are seldom found in an organization's existing data base. A close look must be taken at the perennial data-gathering problems of establishing an information collection system to meet most needs and to provide answers to the following questions relating to data problems:

"If there is a data problem, let's solve it once and for all by establishing the information collection system to meet all our needs."

"How can there be a data problem"? For years, Government and industry have considered establishing cost data bases. Acquiring a major weapon system involving both DOD and contractor organizations includes determining mission needs and requirements, defining performance parameters, establishing force structure, and identifying other system characteristics. A data base system is generally viewed as a centralized manageable repository of an organization's data (hardware, software, procedures), and specialized personnel tasked to handle such a repository.

When tasked to develop the cost estimate(s) for a new helicopter system, the estimator faces a challenge in locating valid data. The type and quantity of data required by modern analytical technique are seldom found in an organization's existing cost data base. Developing a multi-use data base then becomes the obligation of the organization and, given the difficulty, cost, and effort involved in obtaining "good, clear" data, that data should be preserved and used for other purposes. A readily accessible, properly structured data base can be one of the organization's most valuable assets in the problem-solving process. The estimator must act as the controller of such specialized knowledge.

Each new aircraft program defines its data requirements and gathers and stores that data with little coordination with other elements. The resulting data system is typically a fragmented, overlapping collection of files, depending largely upon the originating program for definition, storage, and access procedures. Redundancy results and the data once stored cannot be revised without changing programs. More important, relatively high conversion costs limit potential for future integration of programs and data.

This then, the concept of a data base, is structured around the specific need(s). Continual review must be made of the facets of the cost data bases--functions of the data base, benefits we need, specific response(s) we want, problems we must address, and objectives in handling data.

And what are the common problems experienced?

- Lack of common data source.
- Lack of structured data for estimating.
- Inconsistency in data usage/application.
- Excessive data search time.
- Lack of program historical data.
- General data inaccessibility.

We are faced with a dichotomy as we feel that high technology is the key to maintaining the qualitative edge. In the name of performance, we have introduced a degree of complexity and risk that we have difficulty in systematically costing, managing, and controlling. We also see that while we may understand several technologies individually, we frequently have difficulty with their integration. Let's take a look at the following.

The Cost Illusion. Forecasting cost is always difficult, but it is a special problem for systems that do not yet exist. For instance, how does one evaluate the R&D risk of making a weapon work when the weapon exists only as an idea? It is easy to assume that progress will be smooth and, indeed, the assumption is reinforced by the difficulty in putting funding wedges into budgets for "unforeseen difficulties."

Operations and Support Costs. These costs are very easy to underestimate. Contractors often claim that new weapons require less maintenance, fewer spare parts, and fewer personnel than existing weapons because of state-of-the-art technology, labor-saving devices like built-in test equipment, and efficient management systems. Most often, the delivered product does not live up to those forecasts and the resources set aside for the weapon's support are so insufficient that the weapon limps along.

Even systems already in production are prone to underestimation because it is assumed that cost will decline significantly over time as both labor and management learn how to do their jobs more efficiently.

Unfortunately, actual reductions in cost have often been limited or non-existent. The Army produces too few units and has too many upgrades, design modifications, and engineering changes to provide the required program stability. As a result, future units often cost much more than expected.

OBJECTIVES AND METHODOLOGY

Learning Objectives. Demonstrate a thorough understanding of the various data collection procedures and methodological techniques performed at the installation level.

Demonstrate a thorough knowledge of the process of cost study development, the validation process, and economic analysis.

Demonstrate a general knowledge of other supporting elements of the cost analysis function at various levels of command in the Army.

Understand and be able to discuss the relationship of cost analysis to other functional areas.

ROTATIONAL ON-JOB-TRNG	HOURS
Cost Analysis Policy	40
Cost Analysis Concepts	40
Cost Estimating Methodologies	520
Data Collection and Analysis	280
Cost Studies	480
Validation Process	200
Economic Analysis	240
ORSA Techniques/Interfaces	120
Command Functional Area Trng	40
ADP Orientation	76

The commitment of the cost estimator is to provide assistance to the decisionmaker by providing him with what he really needs to know, especially insights into hard, previously unaddressed cost implications and to provide this in time for him to use it. Cost estimators must communicate clearly what study results are, what it is assessed, what the cost strengths and limitations are, and how these bear on the decisions to be made.

The cost estimator must consistently demonstrate the ability to anticipate changes, to set direction and to organize quickly and efficiently in that direction. In addition, the estimator must continue to seek out new theories, data, methodologies, and applications.

The Cost Analyst is a multidiscipllined professional who employs a wide variety of skills and techniques in successful accomplishment of his cost analysis duties. The ideal Cost Analyst has a composite of the following disciplines: operations research, engineering, economics, and statistics. He is qualified to work with engineers, scientists, and systems analysts on cost-effectiveness and trade-off studies directed toward the identification and selection of optimal alternatives.

The continuous in-depth cost study output demanded for all possible/impossible alternatives to programs includes the impact of stopping or stretching out programs, fluctuating funding requirements, cost comparisons of major modifications to old systems vs. proposed new designs, operational scenarios, etc. This added emphasis on cost analysis is expanding in its mission to investigate new technologies, to develop additional quantitative tools, to analyze these technologies, and to provide sound recommendations for decisionmaking.

To best respond to the acceleration of technology, our immediate needs are to address the impacts by the many new technologies, from the recognition of the need for expanded knowledge and analytical skills, new sources of cost data and research on materials, for the trends of types of tasks assigned, and for the coping with the perennial problems of analyses as associated with the acquisition and the logistical support of Army helicopters. We have found that the use of the five basic steps, systematically followed, of cost estimating is still effective, i.e., the first is to understand the problem and to divide it into its element. Second, gather data upon which to base the estimate. Third is to develop cost estimating relationships. Fourth is the proper use of the estimating relationship, and fifth, to present the result. There remains the need for expanded knowledge and analytical skills, searches for sources of cost data and research on materials, analysis of the trends of types of tasks assigned, and for the coping with the perennial problems of analyses associated with the acquisition and the logistical support of Army helicopters.

Let's take a look at some international aspects: Cost analysts are charged with establishing credibility, accuracy, and cost effectiveness in high technology projects, processes, products and services. As we are all aware, we have entered a period of intensified economic competition and increasing complexities of technologies. Examples of such rapidly expanding technologies include electronics, advanced materials, software and automation. There is intense international competition for leadership in these technologies and recognition is growing that many industries are working together cooperatively in technology ventures.

Many industrial organizations find themselves either wanting to deal or already dealing with the international community. This strong movement towards international cooperation and the linking of Government, industry and the academic sectors of many countries stems from the need to share and exchange technologies.

Cost analysis/cost estimating must be intimately aware of the scope of scientific developments and financial developments in the worldwide environment. Joint ventures with foreign partners not only assist in the exchange and the pooling of scientific knowhow, but they also spread the financial risks. Together, such joint ventures work out solutions to such common problems as currency exchange fluctuations, variations of inflation rates among countries, differences in technology, manufacturing techniques and quality standards, technology transfer, burden, profit rates and royalties. Analysts must seek insights into an array of cost issues, methodologies, the providing of new ideas and new techniques for the professional handling of these issues.

Government and industry have to understand the environments, both near and far term, to help make the many trade-offs we must face in the future--trade-offs between cost and performances, near-term expenditures and long-term production savings and so on. The potential interchanges will result in cross fertilization of ideas, experiences, techniques and methodologies, enabling all parties to address cost more realistically.

Military electronics is a good example of rapidly increased complexities. Using our historical data with adjustments for complexity, similarities and differences, projections are inadequate for these newer technologies. The historical costs may not reflect the higher costs for increased developmental testing, quality control and compliance with pertinent specifications. Consideration must also be given to the costs associated with facilities, training and licensing necessary to handle, store, and test components from development throughout production phases. Cost analysts, cost engineers and procurement pricing personnel must remain abreast of technology advancements to comprehend the ramifications of design specifications, design requirements, and the ultimate cost of production.

Regarding the future, the cost community is looking at the following:

-Continuous development of a broader range of products (be proactive).

-Continuous staffing of the organization with highly competent people capable of growth.

-Improvement of cost studies/reports to provide accurate and timely information.

Requirements to consistently demonstrate the ability to anticipate changes, to set direction and to organize quickly and efficiently in that direction. In other words, we must respond to technological change with:

-More sophisticated studies (in some cases).

-Broader applications (wider range).

-Continuous training to respond to emerging technologies.

It must be emphasized that to thrive as a discipline, the cost community must continue to develop new theories, methodologies, and applications.

CONCLUSION

The cost analyst's professional efforts, no matter what employer, address diverse but interrelated technological products, projects, and innovations, all emphasized by the current topical interests. These products continue to merit significant impact because of the insistence for accuracy, realism, and substantiation. We must be a proactive leader in several technically professional areas in establishing and strengthening networks with many of the recognized experts in Government, industry, and academic institutions. The experience of our community's "state-of-the-art" efforts, along with its established credibility, continues to make the cost analyst much sought after for his expertise in diverse subject matter.

Our tasks increasingly require skills for the organization, direction, and coordination of a constant stream of difficult analytical studies which demand quick reaction that is suitable to varied contingencies in the performance of assigned technical activities. Strong commitment has to be effected in the application of analytical techniques, automated modes, and economic analysis to the complex studies involving logistics and military hardware.

We have entered an era of declining resources and personnel constraints which has created intense competition for resources and conflicting task priorities. There is a noticeable trend that cost analysis is challenged with a variety of unresolvable problems concerning high priority functional assignments and the arbitrary shifting of resources. This era of resource scarcity is having a significant impact on all of us who are now required to be a part of cutbacks, tradeoffs, reallocations, organizational contractions, program cutbacks, growth slowdowns, zero growth, and absolute decline.

We must continue to be known as knowledgeable workers who have a high level of education and expertise; one of our foremost challenges is to keep ahead or abreast of an ever-changing and turbulent pattern of environments. Our efforts are measured by qualitative outputs that are subjected to intensive examination at successively higher levels of management where there is the challenging of the assumptions and appropriateness of the analysis presented and, when finally approved, become standards against which the performance of a variety of managers/organizations/hardware is evaluated. Our input, our participation, is of significant importance in the DOD decisionmaking process.

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ASSESSING AFFORDABILITY UP FRONT IN THE ACQUISITION PROCESS

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ABSTRACT

Much of the ongoing effort to improve the DoD acquisition process is focused on the Pentagon's formal acquisition decision process; yet requirements and acquisition alternatives which ultimately drive costs are often influenced or even guided by pre-Milestone 0 activities, often years in advance of the formal decision process. Unfortunately, affordability is seldom a first order consideration during this formative work. It is common practice among the organizations developing requirements and preliminary concepts to avoid cost as an issue. It is the author's thesis that affordability can and should be addressed earlier in the acquisition process - in the mission analysis and requirements development phase prior to Milestone 0, and in the concept definition work that occurs prior to and after Milestone 0.

In this paper the author critically reviews relevant aspects of the current acquisition process with a focus on the lack of realistic affordability assessments during pre-Milestone 0 activities. He then proposes the development and use of mission effectiveness and requirements analysis methodologies and tools which would permit DoD users to explicitly quantify requirements vs. cost relationships - leading to the creation of requirements which are affordable from the outset. He then reviews examples of pioneering work in the integration of engineering and cost disciplines in concept definition and preliminary design and proposes the development of improved cost engineering tools to integrate cost earlier in the concept definition process.

The author concludes that improved affordability assessment and cost engineering would markedly improve the requirements process, management of acquisitions and the credibility of DoD's budget submission to the Congress.

INTRODUCTION

Our personal acquisitions and those of corporate America are driven by affordability. In contrast, DoD acquisition is most often driven by <u>requirements</u>. Let me illustrate. When our automobile approaches the point of replacement we shop for a new one with an acceptable cost range in mind. We might whimsically conceive the argument for the enhanced performance of a Ferrari Testarossa but quickly put it out of mind as not within the bounds of affordability. Corporate financial managers likewise put extraordinary emphasis on the management of capital improvement funds, and always within the bounds of corporate priorities and fixed budgets. In both of these illustrations affordability is the highest consideration, and requirements and acquisition alternatives are tailored to fit within fixed budgets. While I can argue that DoD is also constrained in the same ways and ultimately acquisition decisions must be based upon the same criteria, the front end of the DoD acquisition process does not similarly bound requirements and acquisition alternatives within the constraints of affordability.

Requirements and acquisition alternatives which ultimately drive costs are often influenced or even guided by pre-Milestone 0 activities, often years in advance of the formal decision process. It is frequently the case that the organizations developing requirements and preliminary concepts are encouraged or directed to avoid cost and affordability as an issue. The result may be requirements which seek to achieve the best possible performance against potential threats with little understanding of the relationship between the required performance and cost. It is my thesis that affordability can and should be addressed earlier in the acquisition process - in the mission analysis and requirements development phase prior to Milestone 0 , and in the concept definition work that occurs prior to and after Milestone 0 - and that doing so would improve the requirements process, management of acquisitions and the credibility of DoD's budget submissions to the Congress.

As a prelude to topics in this paper it is important that I define what I mean by affordability. I have chosen to define affordability in the following way: "A requirement or acquisition alternative is affordable if it represents the best allocation of scarce resources to maintain or improve overall military capability within fixed budget constraints." While this is more narrow and comprehensive than the term normally implies, it is useful for thinking about affordability in the context of the DoD decision process.

I begin by describing relevant aspects of the current acquisition process and commenting on its shortcomings from my point of view. This will set the stage for later analysis and recommendations.

RELEVANT ASPECTS OF THE CURRENT ACQUISITION PROCESS

Pre-Milestone 0. The Packard Commission Report, April 1986; Secretary Cheney's Defense Management Report to the President, July 1989; the recent GAO Report 90-90, Defense Acquisition, May 1990; and other recent acquisition initiatives have focused on improving defense acquisition management at the Pentagon level.[1,2,3] Unfortunately, Pentagon decision makers get much of their data from field activities - users, developers, and contractors - and many of the acquisition alternatives are influenced or guided by these organizations MUCH earlier in the acquisition process. Important aspects of the pre-Milestone 0 activities are: mission analysis and requirements analysis (often referred to as "requirements pull"), technology planning and technology base programs ("technology push"), concept definition studies, and military utility analysis.

Mission Analysis and Requirements Analysis are ongoing activities conducted by the Unified and Specified Commands and the Service's operational commands (hereafter referred to as the users). The traditional approach to mission analysis and requirements analysis can be described as a set of rational steps leading to requirements for new or upgraded systems. Important steps include an assessment of the current and future threat, a statement of national security objectives relative to the threat, development of military requirements necessary to meet those objectives, an assessment of current capabilities to meet those requirements, identification of deficiencies, and the resultant need for new or upgraded systems. One of the shortcomings of this approach is that affordability is seldom explicitly addressed. In fact, some argue that users define requirements and it is up to someone else to define solutions, estimate costs and assess affordability. This approach can lead to "gold-plated" requirements to meet robust threats or achieve the best possible performance against the threat. It is often the case that users define requirements with little insight into the potential costs of meeting those requirements. In their defense, most users have only limited knowledge of the technology, cost, schedule and development risk associated with meeting those requirements. Perhaps for this reason, some argue that operational requirements should be "pure" and deliberately avoid assessment of costs - waiting instead for the Services developing agencies (hereafter referred to as the developers) to feedback costs during concept definition.

Another important influence on requirements is the potential availability of technologies which would give us a decided military advantage. In the history of military systems over the past 40 years, many of our fielded systems were created as a result of technical opportunity rather than being preceded by stated requirements. Advancing technology frequently opens the door for improved capabilities and requirements often follow. Today, the users are deluged by technologists, developers and contractors trying to sell ideas for new requirements. At times, these *technology* opportunities have only a remote relationship to stated needs. Care must be taken that we do not establish a requirement for something just because it is possible. I will talk more about this subject later.

The lack of early consideration of affordability leads to another common problem in acquisition planning - a lack of balance between mission functional elements. There have been many examples of this over the past twenty years. A new fighter aircraft is armed with aging missiles because the combination of aircraft and missile developments became unaffordable; a modern weapon system is hampered by an obsolete C3 system; we field an expensive new surveillance and tracking system but have no money for the associated weapons upgrade. Questions such as, "What portions of a mission area budget should go to surveillance vs. weapons vs. C3?" are often not deliberated. Planners create requirements for all system elements and it is often the budgeters or the Congress that later decide which requirements will be funded, many times with little consideration of the overall balance of interdependent systems. Unfortunately, in an environment of intense competition for funding, users sometimes support this process with a "take what you can get - and fight hard to keep it" mentality. All of these factors contribute to the imbalance we find among various mission functional elements.

Another problem in the requirements process is "concept" driven requirements. In these cases, attractive concepts lead to a definition of requirements that can only be met by high cost, high risk technologies. The question that is difficult to address is: What makes a requirement important enough to warrant an expensive high risk program; how do we quantify benefit vs. cost; and how do we assess affordability relative to the total mission area budget? A closely related problem is the one of preconceived solutions that effectively limit alternatives. These biases are often institutional - driven by desires to grow mission areas or protect "turf," or they support basic roles and missions issues among Commands and Services. In some instances, contractors have also complained that concept driven requirements were over specific and limited their ability to respond with better or lower cost alternatives.

My final point in the discussion of the impact of requirements on affordability is joint requirements. DoD has implemented an effective process for coordinating and developing joint requirements, however, the process for multi-mission and multi-service affordability assessments is far less mature. For example, recent events in the Persian Gulf have pointed to the need for improved worldwide communications. How will DoD determine the allocation of future improvement costs among mission areas, Services and Commands; and how will we assess the affordability of potential solutions?

An important aspect that should not be overlooked is that all of these factors are in play in a continuing requirements process that begins well ahead of the formal decision process, sometimes years ahead, and that they have a significant impact on the ultimate cost of systems - yet affordability is often not seriously considered during this timeframe.

Technology Planning and Technology Base Programs. As I briefly mentioned in the requirements discussion, many requirements are developed as the result of technology advances that make new concepts achievable; rather than being driven by threat and national security objectives. Sometimes this is the best approach, especially in cases where no hard requirement has been established because no potential solution could be conceived. In other cases, it is technology push looking for a sponsor with a requirement and money. Users are deluged by technologists in and out of government looking for a documented need that can be used to justify technology funding. These technology marketers often sell their wares using overly optimistic performance and costs and downplaying risk. There are countless examples of technologies that were touted to be nearly off the shelf that ended up being ten more years in development before they could be applied; and there are some technologies which never reached their promised maturity. Americans in general are fascinated with new technology and so we easily fall into this trap.

In assessing the potential of new technologies it is important that we look beyond the technology to the system level concept and evaluate the concept within the context of the total military environment - and assess the benefits and affordability at this level. As an example, the value of a new acoustic sensor for submarines should be determined by the net improvement in submarine detection and the impact of that improved detection on the submarine's mission. Does a 20% improvement in detection range translate to greater probability of acquiring and destroying an enemy submarine? Or is detection range a secondary factor in probability of kill? The technologist will sell us the improved detection range. The questions we should ask include the impact of that improvement on mission effectiveness and ultimately, benefit vs. cost and affordability.

In assessing the value of new technologies and justifying their funding, we should subject them to more rigorous mission effectiveness studies, evaluate the results in terms of benefit vs. cost, and affordability. Technology push should support affordable concepts and affordable requirements.

Concept Definition Studies. From a Pentagon perspective, concept definition studies (now Concept Direction Studies) are directed at Milestone 0. However, the developmental plans organizations within the developing agencies are engaged in informal concept definition studies (I will continue to refer to them as concept definition studies to discriminate from formal Concept Direction Studies directed by the DAB) on a continuing basis, again often years ahead of Milestone 0 and many times ahead of operational requirements. These organizations are in continuous pursuit of next generation systems with better performance or lower life cycle cost, with strong motivation - building the future for the developing agency. "Pet" concepts developed by these organizations are frequently marketed to the users to encourage establishment of requirements and build advocacy for the concepts. Often, by the time formal Concept Direction Studies are directed by the DAB these pet concepts have well established "camps" supporting them within the development and user community and the formal studies serve to rubber stamp these predetermined solutions. In an attempt to create advocacy for these new concepts, developers are motivated to overstate potential capabilities and understate costs and development risk. These concepts are frequently not subjected to rigorous mission effectiveness studies, benefit vs. cost analysis, and assessment of affordability within the potential user's mission area budget. In their defense, the developers are not the right organization to perform these studies - they have a built-in conflict of interest - they are ultimately not the buyer, but the seller.

The point to be made is that the developmental planning and informal concept definition in the pre-Milestone 0 timeframe does much to influence the future acquisition long before the Pentagon's formal decision process. Given this, a strong effort should be aimed at improving military effectiveness analysis and assessment of affordability at this stage. This leads me to the final topic in this section.

The Role of Military Utility Analysis. Military utility analysis can be viewed from two points. The widely used definition focuses on assessment of the military value (benefit vs. cost) of alternative system concepts. This is an important quantitative analysis that should be used earlier and more rigorously than it is in many acquisitions. The second form of utility analysis focuses on the military value of meeting specific requirements and is more useful in assessing whether a given mission should be performed and at what level. This latter form of utility analysis is used far less frequently, but should be considered more in a budget constrained environment. Let's look at the first form.

Military utility analysis is called for in the formal acquisition decision process at various milestones. The rigor with which it is performed at the early milestones is an important aspect of Secretary Cheney's initiatives. Hopefully, from the earlier discussion of the requirements process and the development planning concept definition studies, it should be clear that utility analysis has a potentially important role in pre-Milestone 0 activities as well, particularly with respect to the early concept definition work. One could argue that utility analysis should be the basis for continuing or rejecting concepts during this stage. The point is that military utility analysis should have a role much earlier in the acquisition process. To be valid, both the user and the developer must participate in this analysis since the developer is in the best position to evaluate system performance and potential cost and the user is in the best position to evaluate the military effectiveness and value of the concept. Unfortunately, many utility analyses are flawed to some degree by a reluctance to compare mission alternatives which infringe on Service or Command "rice bowls". Multi-mission and multi-service utility is frequently difficult to quantify because of the complex problem of assessing value across mission areas and Services.

The second form of utility analysis, the utility of performing a specific mission and at what level, is used less frequently but is potentially more valuable. This should be solely within the purview of the user and performed routinely during the mission analysis and requirements process. Traditional war-gaming analysis coupled with modern cost estimating relationships and historical mission area costs could form the basis for this work. As an example, the ability to answer the questions: "Are the benefits of world-wide air surveillance worth the potential costs?" or alternatively, "At what cost does world-wide air surveillance become attractive?", is important in determining if a requirement for wide-area surveillance should be established or is affordable. Unfortunately, we are frequently unable to answer these kinds of questions; a strong argument for linking military utility analysis to the requirements process.

The reader should bear in mind that up to this point we have been discussing pre-Milestone 0. A brief discussion of the formal acquisition milestones follows.

Milestone 0. One of Secretary Cheney's July 1989 defense management initiatives was to charter the Joint Requirements and Oversight Council (JROC) to review the validity of the identified mission needs and assign a joint priority to a program prior to the DAB for Milestone 0. The DAB then evaluates the requirement in the context of the fiscally constrained acquisition environment and approves Concept Direction Studies. An important point to note is that at this point the acquisition process has already become largely requirements driven. The requirement has been validated and the opportunity to "challenge" the requirement is diminished. As a result, the opportunity for requirements vs. cost trades is small and trade studies focus on performance vs. cost and selection of the lowest cost to meet requirements. As I pointed out earlier, user and developer advocacy are frequently already well developed, favored concepts selected and supported, and affordability downplayed (unless low cost is a selling point). In many instances the Milestone 0 Concept Direction Studies simply rubber stamp and refine the pre-Milestone 0 work - where affordability often has not been a major factor. The DAB seldom has the quantitative information to make an evaluation of the military value of meeting the identified requirement or the affordability of meeting the requirement within budget constraints. The result is that many potential systems receive Milestone 0 approval without a thorough understanding of the impact of pre-Milestone 0 decisions on the requirement, alternative concepts and ultimately the potential cost of the candidate system.

Milestone I focuses on concept approval. At this point the concept(s) has been refined to "meet requirements", program objectives are well established by the developer and program advocacy by both user and developer is usually strong. While a review of requirements vs. cost trades is a Milestone I objective, the advocates have frequently worked hard to insure that concepts will "meet requirements" and the focus is on performance vs. cost. While the DAB is diligent in their assessment of the various factors, their information has already been influenced by the many pre-Milestone 0 factors we have already discussed. An initial affordability assessment is undertaken but may be limited to a rough definition of out year costs and an evaluation of whether the costs will "fit" in the projected DoD budgets. An assessment of affordability, as I have defined it for this paper, is frequently left to later milestones.

Milestone II. Unfortunately, studies have shown that as much as 50%-60% of the costs have been designed into a system by this point - much of it as the result of the pre-Milestone 0 activities I have described earlier.[4] At this point alternatives are restricted, user and developer advocacy is strong, and it is a serious question whether we are already too late to influence many of the costs. DoD may be faced with a "go or cancel" decision. The motivation to compromise performance and cost to "save" the program is also strong. We can argue that assessing affordability at this point is too late. It gets even worse at later milestones.

Hopefully, you are now convinced that affordability has not received sufficient emphasis in the front end of the acquisition process and that delaying affordability assessment has unfavorable impacts on the formal acquisition decisions. It is my thesis that earlier affordability assessments are achievable and I will provide the rationale for that thesis in later sections of this paper.

First, I would like to go back to the basic definition of affordability to dispel a potential problem. To assess affordability one needs to determine what is affordable. Well disciplined analysts might argue that even if we could confidently determine cost we have no basis for determining affordability. I might have countered, prior to the major changes in Eastern Europe, that the allocation of the DoD budget among the mission areas and Services does not fluctuate dramatically and in fact remains constant or varies slowly over time. Now, it seems likely that there will be a realignment between the strategic and tactical mission areas. Regardless, to address affordability in a meaningful and disciplined way, as I have suggested earlier, the users and developers require some form of affordability guidelines. It is not the purpose of this paper to delve into ways of creating these guidelines. A straightforward breakdown of mission areas and elements to the point that concepts and acquisitions are developed to meet specific needs, and then allocation of budgets to each of these levels appears feasible and is consistent with current budget planning activities. Various master plans requested by the Congress and created by the Services in recent years, move in this direction but frequently focus on systems rather than mission elements. For the purpose of limiting this paper I will assume that such guidelines can be created - since budget allocations to mission areas is already a reality.

ASSESSING AFFORDABILITY IN THE MISSION ANALYSIS & REQUIREMENTS DEVELOPMENT PHASE (Pre-Milestone 0)

Traditional mission analysis and requirements analysis were described briefly in earlier sections. It is not my contention that this traditional approach should be scrapped. Rather that it should be made more robust and expanded to focus on the benefit vs. cost of performing specific missions and the tradeoffs between mission performance levels and cost. Important new products from this approach should be: 1) a clearer understanding of the relationship between requirements and cost, 2) requirements that are affordable from the outset, and 3) requirements that are defined in terms of performance vs. cost relationships with boundaries of acceptability for guiding concept development.

The advantages of integrating early affordability assessments into requirements development assumes of course that the methodologies, skills and tools to perform requirements vs. cost trades exist or can be developed. There have been a limited number of government sponsored efforts and independent contractor efforts which have addressed at least part of the problem, however, no comprehensive set of methodologies and tools have been developed. The efforts to date have demonstrated that methodologies and tools can be developed with some confidence. The SDI system architecture studies chartered by the SDIO during the early years of the SDI program focused on system level performance vs. cost in constructing candidate architectures. These studies started with mission effectiveness (number of reentry vehicles negated), translated this to specific surveillance and weapon effectiveness, sized candidate system concepts and used cost estimating relationships to determine first order costs. The resulting mission effectiveness vs. cost relationships guided early architecture and concept selection. In 1983, the Air Force and Army sponsored studies of advanced SDI concepts which included development of system and sizing models for space-based weapons. These studies employed methodologies which translated systems level performance parameters into subsystem performance, sizing and cost.[5] These studies could have been coupled to mission effectiveness models to again create mission effectiveness vs. cost relationships.

Air Force Space Systems Division sponsored work on a "Requirements Budgeting" methodology which takes into account performance and cost considerations in translating system performance requirements to lower tier requirements.[6,7] This was also a useful step toward a requirements vs. cost model. I am sure there are other examples of work which address aspects of the problem. My only intent is to illustrate that there has been work in this area. However, the concept of requirements vs. cost has not received wide endorsement and there does not appear to be a focused effort to improve DoD capabilities in this area. It should be pointed out that for purpose of requirements vs. cost trades at this early stage the cost models need only assess rough order of magnitude costs. If requirements appear affordable these costs will be refined further during concept definition studies and throughout the life of the acquisition.

Implicit in this approach is the need for the users to have the skills and tools in place to perform these analyses. Roles and missions conservatives will argue that the users should leave this work to the developers. However, I argue strongly that the way of doing business today fails to bring affordability into play early enough as witnessed by the many programs which reach advanced development and then must be scaled back in performance, force structure, delivery schedule and cost in order to be affordable - often at costs disproportionate to the final product. I also argue that this approach simply provides the users with the knowledge and tools to become smarter consumers; and it provides a method of checks and balances between the users and developers during the early phases of the acquisition process. The ability to understand the relationship between potential requirements and cost should be a necessary ingredient in requirements planning and development. The potential value of beginning the acquisition process with affordable requirements from the outset is important.

The potential benefits from this approach, and the overwhelming need to reduce acquisition costs argue for the development and refinement of appropriate methodologies and tools which can be used by the DoD users.

ASSESSING AFFORDABILITY IN THE CONCEPT DEFINITION PHASE

Consistent with my principal focus, this section is aimed at pre-Milestone 0 activities, however, it is equally applicable to Milestone 0 activities. Given the development and use of capabilities proposed in the previous section the developers would begin concept definition studies with requirements already constrained by affordability. In this section I will present the argument for earlier integration of cost into the engineering process, point to some pioneering work in this area, and argue the potential payoff of pursuing the development and refinement of cost engineering models.

Traditional concept definition work can be characterized by a chain of events: requirements, concept formulation, preliminary design, and cost estimating; followed by continued design work and refined cost estimating in an iterative loop until satisfactory results are achieved. It is most often the case that engineers design to meet performance requirements and then turn over designs to cost estimators for the "good news or bad news". The relationship is far more adversarial than team oriented as witnessed by the fact that in almost all developer and contractor organizations engineers and cost estimators belong to separate "shops" under different management. (I am not arguing that independent cost estimating should not be performed). Engineering models have a heritage based upon engineering and performance relationships and there has been little effort to integrate cost into these models. Cost estimators on the other hand are often used by program managers as a "police force" to keep the engineers in line. Historically, there has been no overriding motivation to create an engineering-cost team. The disadvantage inherent in this approach is that countless engineering hours are spent on designs that are rejected due to cost and must be continually iterated until an acceptable design and cost are achieved. Or, in the absence of affordability criteria, costs may simply be accepted. In the race to get the most from every acquisition dollar there is compelling argument to force an integration of the engineering and cost disciplines at the earliest possible point in the concept definition process.

Integrated engineering and cost (sometimes referred to as cost engineering) provides the basis for improving our concept definition process.[8] This requires that preliminary design teams integrate engineering and cost estimating disciplines and skills at the lowest level; and that we develop and integrate engineering cost models. Many existing engineering and cost models should be enhanced to provide this capability using suitable computer software environments as a framework. Continued refinement of integrated cost engineering relationships will enhance capability over time. The concept of cost engineering is certainly not new, however, it is not yet widely accepted and used in the developer and contractor community; and there is not a comprehensive set of methodologies, algorithms and tools available.

One example of pioneering work in this area is the Air Force Space Systems Division program to develop and use cost engineering concepts.[9] They have developed a complex, highly organized and integrated software framework which handles over 100 inputs (requirements, threat, technology, cost) uses over 300 engineering algorithms and over 50 cost estimating relationships, which they are using in a pilot program. They cite potential advantages as: integrated design and cost trades; highly visible design and cost assumptions; clear traceability of cost to performance; explicit cost of technology; and enhanced design to cost capabilities.

While there are a few grass roots efforts going on in this area it is not receiving attention and priority consistent with the potential advantages it offers in terms of improved concept definition.

CONCLUSION

Much of the ongoing effort to improve the acquisition process is focused on the Pentagon's formal acquisition decision process; yet much of the potential cost and many of the acquisition alternatives are established and guided by pre-Milestone 0 activities. Pre-Milestone 0 mission analysis and requirements analysis activities begin to drive requirements, concept definition, program advocacy, and eventual program cost, well ahead of formal Milestone 0, sometimes by years. At times, affordability receives little attention until the formal decision process. I have argued in this paper that affordability should and can be addressed earlier in the acquisition process - during requirements development and in preliminary concept definition. The methodologies, skills and tools required to provide early visibility into cost and thence assessment of affordability are achievable. Pioneering work in this area has already demonstrated some of the basic concepts. The issue is one of placing increased priority on the development and refinement of these capabilities and a change in operating philosophy that makes these tools useful in the acquisition process. It is my strong belief that the potential benefit of this approach argues for changing the way we do business.

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COST-BENEFIT COMPARISON: A METHOD FOR EVALUATING PROPOSED CHANGES TO DEFENSE ACQUISITION PROCEDURES

By Captain Ted McIntire, HQ ASD/AEMP

ABSTRACT

Defense acquisition procedures are changed with the intention of improving the method of acquiring defense products and obtaining better defense products. It is possible that some changes to improve defense acquisition procedures have the effect of degrading defense acquisition procedures.

Evaluating the impacts of proposed changes to defense acquisition procedures may preclude the adoption of those changes that are degrading to the defense acquisition process. This paper discusses a method of identifying, comparing, and analyzing the advantages and disadvantages of proposed changes to defense acquisition procedures. This method, named cost-benefit comparison, was developed following a review of the defense acquisition environment, and a review of existing evaluation tools and management theory. This paper also resulted in the preparation of a sample cost-benefit comparison for a potential change to defense acquisition procedures.

INTRODUCTION

Defense acquisition procedures are changed with the intention of improving the method of acquiring defense products and obtaining better defense products. It is possible some changes intended to improve defense acquisition procedures degrade defense acquisition procedures. It is possible that the comparison of the advantages and disadvantages of a proposed change to defense acquisition procedures will preclude the adoption of those changes that are degrading to the defense acquisition process.

Importance. If changes to any system are made and those changes result in greater costs than the benefits derived, then the net cost of the change is satisfied through a decrease in system performance. Defense acquisition can be viewed as a system that converts inputs consisting of resources into outputs in the form of defense products. The defense acquisition system functions within the system of national policy, which also converts inputs in the form of resources into outputs in the form of achievement of national policy objectives. Any change made to either system will affect the way in which these systems convert inputs into outputs. If a change is made to either system and the costs of the change are greater than the benefits, then the system will function at a lower efficiency. The result of this lowered efficiency will be that decreased outputs will be achieved with the given input, or increased input will be required to achieve the previous level of output.

For defense acquisition, decreased outputs would translate into fewer or poorer quality defense products produced with the inputs provided. The requirement for increased inputs would translate into more money, time, or manpower necessary to acquire the same output and quality of defense products. It is for these reasons that the study of how changes to defense acquisition procedures are evaluated is important.

The applicability of the acquisition procedures followed by defense acquisition offices is a prime indicator of the quality and quantity of the nation's war fighting materials. The use of cost-benefit comparison to analyze changes to defense acquisition procedures will help insure beneficial changes are made to the procurement process, thus increasing the value of the defense products produced.

The entire military community is passing through a period when improved performance is being requested from organizations that are being provided with the same or a smaller amount of resources. Improved performance cannot be achieved without the use of new technology that would allow for an improved output with a given amount of resources (13:9). Savings can only come about from new or improved methods of operation. The investigation of new analysis techniques, to include cost-benefit comparison, must be conducted to identify new methods to increase the efficiency of defense acquisition procedures.

Added to this is the changing environment the military acquisition community is faced with. Changes in the form of increasing regulatory direction have been brought about by a perceived need to correct a poorly functioning military procurement system. These changes have an enormous potential for affecting the efficiency and effectiveness of defense acquisition procedures. The necessity for an evaluation method can be appreciated when considering the increase in regulatory reform.

> The regulations governing business operations of the Defense Department and private industry have increased markedly since World War II. In 1947, the Armed Services Procurement Regulation (ASPR) numbered approximately 125 pages; in 1987, Federal Acquisition Regulation (FAR) and Defense Acquisition Regulation (DAR), the successors to ASPR, constituted several large volumes, totaling approximately 1,200 pages, with new pages added each month. (5:17)

Management of Acquisition Procedures. Defense acquisition procedures are changed to correct problems. "A problem exists when managers detect a gap between existing and desired levels of performance" (2:438). Although an idea for a change may come from within the military, within the government, or from outside the government, there are a limited number of ways a change can be made to defense acquisition procedures.

The primary organizations responsible for directing, controlling, and making changes to defense acquisition procedures are Congress, offices of the Executive Branch, and the DoD (5:18). Each of these organizations has "numerous oversight and monitoring agencies" to aid in controlling the defense acquisition process (5:18,19).

> The executive branch has the Justice Department and the Office of Management and Budget; the Department of Defense and each military service has an independent inspector general and auditing office; and Congress uses the General Accounting Office (GAO) for program audits and assessment, the Congressional Budget Office for budget and program cost estimates, and the Congressional Research Service and Office of Technology Assessment for analyses. (5:19)

Changes these organizations make to defense acquisition procedures can result from legislative action taken by Congress, executive orders issued by the President, or by improvements directed by the DoD (12:5). These changes are put into place by incorporating them into the directives, regulations, and military standards governing the defense acquisition process. In addition, changes made by other organizations within the federal government (such as the CAA Council, the DAR Council, the DOL, the CASB, and GSA) modify defense acquisition procedures. These organizations regulate activities within their area of authority in the federal government and thereby affect federal and defense acquisition procedures (12:5).

How Changes Are Evaluated. A review of literature did not identify any standard procedures to evaluate proposed changes to defense acquisition used by any organizations in the Federal Government. The only procedure for evaluating some of the proposed changes to defense acquisition procedures is described in OMB Circular A-19. Circular A-19 gives directions to Executive Branch departments on the coordination and clearance of department recommendations on legislation (15:1).

Circular A-19 deals with procedures for obtaining Executive Branch approval of department and agency recommendations pertaining to Congressional activities. A-19 does not give much detail on how impacts, or what impacts, should be evaluated. One requirement that is given in the Circular is that budgetary and personnel impacts must be included "for the budget year and for each of the four succeeding fiscal years" (15:4,7). In addition, the circular states that impacts on other areas such as the environment, economics, and paperwork should be considered (15:8-9). Circular A-19 also encourages agencies to "consult with each other in order that all relevant interests and points of view may be considered and accommodated" (15:12).

Within the DoD, Department of Defense Directive 5400.4 describes the policy that regulates the furnishing of information to Congress (3:1). DoD Directive 5400.4 requires all organizations in the DoD to comply with OMB Circular A-19. This Directive does not provide any additional direction on how legislation should be evaluated (3:3,Encl 2).

OMB Circular A-19 and DoD Directive 5000.4 mainly provide administrative guidance on how to coordinate recommendations pertaining to Congressional activities. Neither of these documents requires that proposed changes to defense acquisition procedures be evaluated.

A cost-benefit approach to decision making that was used by an individual influential in our national government was the system used by Benjamin Franklin. A description of this procedure follows.

> In the affair of so much importance to you, wherein you ask my advice, I cannot, for want of sufficient premises, advise you what to determine, but if you please I will tell you how. When those difficult cases occur, they are difficult, chiefly because while we have them under consideration, all the reasons pro and con are not present to the mind at the same time; but sometimes one set present themselves, and at other times another, the first being out of sight. Hence the various purposes or inclinations that alternately prevail, and the uncertainty that perplexes us. To get over this, my way is to divide half a sheet of paper by a line into two columns; writing over the one Pro, and over the other Con. Then, during three or four days consideration, I put down under the different heads short hints of the different motives, that at different times occur to me, for or against the measure. When I have thus got them all together in one view, I endeavor to . estimate their respective weights; and where I find two, one on each side that seem equal, I strike them both out. If I find a reason pro equal to some two reasons cons, I strike out three. If I judge some two reasons con, equal to some three reasons pro, I strike out five; and thus proceeding I find at length where the balance lies; and if, after a day or two of further consideration, nothing new that is of importance occurs on either side, I come to a determination accordingly. And, though the weight of reasons cannot be taken with the precision of algebraic quantities, yet when each is thus considered, separately and comparatively, and the whole lies before me, I think I can judge better, and am less liable to take a rash step, and in fact I have found great advantage from this kind

of equation, in what may be called moral or prudential algebra.

Benjamin Franklin, London, September 19, 1772 (8:1)

Although no specific mention was found of whether Franklin or others actually used this cost-benefit approach while being of service to our government, it is useful to consider his simple and straightforward approach with the understanding that it may provide a good example for evaluating changes.

Evaluation Needed. This apparent lack of standardized procedures for evaluating and communicating the consequences of proposed changes to defense acquisition procedures is alarming. Organizational and management theory indicates how proposed changes to defense acquisition procedures can be evaluated. Decisions pertaining to proposed changes to defense acquisition procedures are in response to unique and hard to measure problems, information about the problem is ambiguous and unclear, the problem may require extensive study, and there may be little assurance that the implemented change will work (2:438,439).

Researchers Vroom and Yetton have developed a model to help identify the appropriate decision style based on the type of decision being made (2:449-453). Based on the desired decision effectiveness of proposed changes to defense acquisition procedures, the Vroom and Yetton model suggests that as a minimum the decision maker should obtain information concerning each decision from subordinates impacted by each change (2:450).

In business organizations it is an accepted principle that "decisions should be made at the lowest managerial level which has access to all relevant data regarding the possible outcome of a decision" (17:8). However, decisions concerning proposed changes to defense acquisition procedures pertain to a nonprofit organization and can be ambiguous, unclear and difficult to measure. "As a result, a high degree of centralization of decision-making" usually results for these types of decisions (17:8). Because decisions concerning changes to defense acquisition procedures tend to be centralized does not mean information and data should not be gathered from lower levels to help decision makers choose the best course of action.

Difficulties Associated with Quantification. A possible reason the analysis of the impacts of changes to defense acquisition procedures is rarely identified in the literature and is not performed routinely is because it is perceived as being too hard to be accomplished. A viewpoint article from Aviation Week and Space Technology identifies the media stories of defense procurement mismanagement as the cause of hundreds of military and private sector oversight personnel being added to various projects at the ultimate expense of the taxpayer. The article goes on to question whether the additional oversight saved anywhere near the amount of money it cost to hire and pay the oversight workers. (14:11)

It is obvious the evaluation of changes to defense acquisition procedures is complex. The findings of an Air University Research Report that reviewed published cost-benefit studies to determine net savings for second-sourcing decisions reveals how difficult this task is. This report found that of all the studies reviewed, none considered all of the impacts (costs and benefits), and of those impacts considered, many were predicted with methods that were not reliable or credible (9:78,109-110). The conclusion reached in the report was that there are too many variables, and there was not enough data, or an appropriate methodology did not exist to complete the cost-benefit studies reviewed (9:xi,78,110).

Although the generation and presentation of specific measurable impacts may appear impressive, consideration of all the assumptions that had to be made, faulty prediction methods that could have been used, and individual biases that may have been factored into the analysis reduces the credibility of those studies and conclusions that rely heavily on measurable impacts.

However, this is not to say the impacts of a decision cannot or should not be addressed. "The cost-benefit way of thinking is widely applicable even if the cost and benefits defy precise measurement" (10:6). Although it would be desirable to express all costs and benefits in the same units of measure this is not always feasible. Cost-benefit analysis should "not attempt to push quantification to meaningless extremes" (4:8). "Benefits and costs should be quantified when they can be and not when they cannot be, but whether quantified or not, they should never be ignored" (8:8). In line with this perspective, the textbook Life Cycle Cost gives "four different levels of precision with which costs can be defined:

1. Dollar Expenditures
2. Other Costs Evaluated in Dollars
3. Other Costs that can be Quantified
4. Other Non-Quantifiable Costs" (7:42).

Although the same textbook refers to benefits as either "quantifiable or subjective" it can be seen that the same levels of precision used above to define costs could be used to define the benefits of an alternative (7:69).

Example. To demonstrate how a cost-benefit comparison could be performed, a cost-benefit comparisons was prepared for a change that might be made to defense acquisition procedures. A review of the completed cost-benefit comparison will allow the reader to evaluate the usefulness and applicability of the cost-benefit comparison method. A method for displaying the results of this Cost-Benefit Comparison in a ledger format was used and has been attached to this paper.

Preparation of a cost-benefit comparison requires a knowledge of the change and an understanding of the impacts of the change. The use of personal evaluation and judgment may be appropriate when initially attempting to identify the impacts of a change, but should be followed by research of available information on the topic. For this reason, the change analyzed for this paper was selected among potential changes that could be made to defense acquisition procedures that had a description of the change and some discussion of the advantages and disadvantages of the change recorded in the literature.

The cost-benefit comparison prepared for this paper considers the advantages and disadvantages of removing existing defense acquisition procedures that require warranties for procured weapon systems. Like any proposed change, this change was selected based on the perception that it might be determined that making this change would improve the defense acquisition process. The preparation of an initial cost-benefit comparison ledger and descriptive summary will help indicate whether the perception is accurate, and whether continued analysis and consideration of the change is warranted. After review of a cost-benefit comparison, individuals and organizations closer to the decision making levels in our federal government can decide if they want to pursue an issue and propose that a change should be made. If it is decided that a proposed change warrants further consideration, the ensuing review and debate over the change will result in a more refined and accurate cost-benefit comparison.

It should be understood that even though the initial product of a cost-benefit comparison should be prepared as objectively as possible, it will be based on the impacts of a change as compiled from a single perspective. The initial or draft cost-benefit comparisons may not accurately reflect all commonly agreed upon areas of impact, and the impacts recorded may be in need of refinement, alteration, or correction. Later draft cost-benefit comparisons would be more precise and closer approximations of the final cost-benefit comparison. This evolution of the cost-benefit comparison to its final form is accomplished through continued consideration, analysis, and evaluation of the proposed change.

A Cost-Benefit Comparison of Warranties. Changes were made to defense acquisition procedures to require the DoD to obtain warranties from contractors for weapon systems obtained at a cost of more than $100,000 per unit, or a total procurement cost of $10,000,000 (18:98 Stat. 2601). This change was put into place by laws created by Congress and is contained in Section 794 of the 1984 DoD Appropriation Act, Public Law 98-212 and Section 1234 of the 1985 DoD Authorization Act, Public Law 98-525.

The law requires contractors provide written guarantees that the weapon systems meet design, manufacturing, and essential performance requirements, and are free from defect in materials and workmanship. If the systems do not meet the required guarantees the contractor must take corrective action or pay necessary costs for the government to take corrective action. A waiver to the requirement for a warranty may be granted as long as the Secretary of Defense notifies Congress that the waiver is in the interest of national defense or if the warranty would not be cost effective. (18:98 Stat. 2602-2603)

Enough articles were located which discussed the impacts of the warranty laws to allow for the completion of an initial cost-benefit comparison. The attached Cost-Benefit Comparison Ledger presents the potential advantages and disadvantages of changing defense acquisition procedures by eliminating the requirement for express warranties on weapon system contracts. The Cost-Benefit Comparison Ledger is followed by a page of text called a Descriptive Summary which contains additional information that would not fit into a ledger format. Because of the many sources of information used to construct this ledger the descriptive summary was also used to record the sources from which information or ideas were obtained. A numbered reference system was used to cite each source used in the cost-benefit comparison. The numbers used to cite each source in the descriptive summary are the same as the numbers used for the sources as they are listed in the bibliography. The ledger and descriptive summary are contained in the appendix.

CONCLUSION

The regulations, policies, and processes governing the operation of defense acquisition offices determines the efficiency and effectiveness of the DoD's ability to supply itself with the weapons and support materials to defend the United States and project military power. The applicability of the contracting approaches followed by military acquisition offices is a prime determinator of the quality and quantity of our country's war fighting materials. This research has documented that a procedure to identify and compare the cost and the benefits of changes to defense acquisition procedures can be created. The use of a cost-benefit comparison technique may improve the performance and output of our defense acquisition process and should warrant further study.

Appendix: Cost Benefit Comparison for Eliminating Requirements for Warranties

COST-BENEFIT COMPARISON LEDGER	Page: 1 of 4
Date: 32 September 1990	POC: Capt Ted McIntire
Change ID: Eliminate Warranty Req-1	Office/Phone: ASD/AEMP (513) 255-6816
ADVANTAGES	DISADVANTAGES
Contractors will not have to charge for warranties (to cover increased risk/liability) and services will no longer have to pay for warranties. (1:38) (16:7) Services will no longer have to pay increased costs to contractors to obtain warranties on every weapon system (11:29,30) Money paid for warranties that cannot be enforced because weapon systems could not be operated and maintained in accordance with warranty specifications will no longer be wasted (7) The DoD can revert to obtaining warranties selectively (as it has in the past). (1:37)	Services will have to make or pay for alterations (corrections) that would have previously been covered under a warranty (and are not otherwise covered by Contract). (11:29)

Form XXX

COST-BENEFIT COMPARISON LEDGER Page: 2 of 4

Date: 32 September 1990 POC: Capt Ted McIntire

Change ID: Eliminate Warranty Req-1 Office/Phone: ASD/AEMP (513) 255-6816

ADVANTAGES	DISADVANTAGES
Resources (manpower, training) necessary for administration and enforcement of guidelines and regulations that implement warranty requirement laws no longer necessary. (11:27,29) Resources (manpower, time, paperwork) necessary to negotiate, review, and obtain warranties on all contracts will be freed. (11:27,31) Services will no longer have to face administrative confusion and costs caused by multiple warranties between services, contractors, sub-contractors, and suppliers. (11:29) Resources (manpower, paperwork) required to obtain waivers to the requirement for warranties (and to perform the cost-effectiveness studies) will no longer be required. (11:29)	

Form XXX

COST-BENEFIT COMPARISON LEDGER Page: 3 of 4

Date: 32 September 1990	POC: Capt Ted McIntire
Change ID: Eliminate Warranty Req-1	Office/Phone: ASD/AEMP (513) 255-6816
ADVANTAGES	DISADVANTAGES
Reluctance to advance or use state of the art methods and subsystems (and the resultant loss in technical superiority), due to high risks and warranty penalties that are associated with new technologies, would be avoided. (16:9) Services will no longer have to endure losses stemming from increased downtimes and rescheduling problems to accommodate individual contractor warranty repair processes. (11:29) Military readiness, which is adversely impacted by increased downtimes and rescheduling delays (that are a result of individual contractor warranty repair processes) will be improved. (16:8) Field training and experience of military maintenance personnel during peacetime would be increased. (16:8)	Contractors will assume a smaller portion of risk, giving them less incentive to provide weapon systems that meet performance specifications. (11:63)

Form XXX

COST-BENEFIT COMPARISON LEDGER	Page: 4 of 4
Date: 32 September 1990	POC: Capt Ted McIntire
Change ID: Eliminate Warranty Req-1	Office/Phone: ASD/AEMP (513) 255-6816
ADVANTAGES	DISADVANTAGES
Sustainability problems during wartime, caused by weapon systems being heavily used and requiring sharply increased warranty coverage that contractors cannot respond to (and as a result must be provided by military maintenance personnel with little or no experience with the warranted systems), will be avoided. (16:8)	
Resources (manpower, databases, reports) used to keep track of systems and their performance, and to enforce warranties will no longer be required. (11:31)	Information concerning weapon system performance generated to comply with warranty requirements may no longer be generated or made available. (11:63)
Analysts will no longer have to struggle because of lack of data when performing warranty cost-effectiveness studies to obtain a waiver to the requirement for warranties. (11:31)	

Form XXX

Eliminating Requirements For Warranties - Version 1

Additional Notes

Advantages and disadvantages relating to the same categories (cost, performance, data) were displayed side by side in groups on the ledger.

The information uncovered in the research did not indicate what level of coverage a warranty provides above and beyond the coverage required by previously existing contract requirements and specifications. It is possible that much of the resources expended to obtain "additional" coverage with a warranty may already be covered by contract, but is not being, or has not been, properly enforced.

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INDUSTRIAL PREPAREDNESS

OUR AMERICAN INDUSTRIAL BASE WHERE IS IT HEADED? IS IT ON THE RIGHT TRACK?

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ABSTRACT

During this decade, the American industrial base will continue to face a challenge to its growth and survival. We are no longer the world leader, technologically or industrially. Questions to be answered are: Can we regain our position in the world manufacturing community? What approach (or approaches) offers the best opportunity to regain the competitive edge? The author examines important issues and directions in the defense industry as well as in the general manufacturing community. The results of three recent studies are summarized. Discussed is European Community 92 and its possible impact on small and mid-size American companies. Further, the author recognizes one of the major causes for the decline in our industrial and economic competitiveness relates to American education. Although the challenges in this area are great, the author concludes that the opportunities are also great.

The big question is whether America has the resolve to correct mistakes and meet the challenges so our nation can regain its position of leadership in the industrial world once again.

INTRODUCTION

This decade is critical to the growth and survival of the American industrial base, which faces unprecedented worldwide competition. The United States lost its place as world technological and industrial leader. High costs, separating product and process design, and delaying decision-making contributed to our loss. We must face the situation head-on to reverse the direction.

We must concentrate on things like manufacturing processes, product quality, and increasing market share. A survey conducted by the East Coast Manufacturing Group, Price Waterhouse, ranked functional areas companies believe offer the best opportunity to achieve a competitive edge; 50 percent ranked manufacturing processes as number one. Quality control and sales were second and third, respectively.

In addition to placing attention on these three areas, our manufacturing industry must take positive steps to promote productivity of human and capital resources, employ the latest technology available, flexibility of manufacturing methods/facilities, and minimize product cost. Even if industry pays attention to these needs and takes appropriate action, there is no clear indication today that manufacturing employment in America will increase noticeably during the first half of the 1990s.

IMPORTANT ISSUES AND DIRECTIONS

Looking at national defense, there are people believing that the U.S. defense buildup will slow during this decade. The U.S. defense budget may decrease 25-50 percent from the 1990 budget. This may cause temporary dislocations for workers in the defense industry and short-term, or worse, setbacks for the industry. At the same time, there would be dislocations in the economy.

The Honorable Donald J. Atwood, Deputy Secretary of Defense, speaking to the National Forum Foundation said, "deterioration of America's industrial base is one of the most pressing issues facing the Department of Defense (DoD)...."[1] Because the DoD buys manufactured goods from more than 250,000 firms encompassing more than 215 industries, the DoD interest in the defense industrial base is inseparable from its interest in the American industrial base. "Indeed," Atwood said, "they are one and the same."

It is necessary that the United States maintain a strong, competitive industrial and economic base if we are to sustain our deterrent capability. When the unified European Economic Community arrives in 1992 (generally referred to as EC 92), American and European defense industries will probably become more competitive. American industry cannot afford to be outmanaged. Hal Sperlich[2] believes the American auto industry lost its competitive edge and one-third of its business to Japan during the last 30 years. He claims our country has been "out-managed." Among other factors were superior Japanese management skills and dedication to economic superiority over the United States.

Recognizing the growing loss of American preeminence in industries and technological areas, the Congress asked the DoD in 1988 to identify technologies critical to long-term viability of national defense. The 22 technologies identified, include semiconductor materials and microelectronics, computers, propulsion, composite materials, and superconductivity. A DoD Critical Technologies Plan (CTP) is scheduled to be published annually and should be valuable for national dialogue and industry planning.

Let's review Congressional actions relative to defense. Procurement reform provisions in Title VII, Department of Defense Authorization Act (Public Law 101-501), will impact on the defense industry. Section 824 says DoD acquisition regulations are to encourage contractors to undertake research and development work that strengthens the defense industrial base, enhances U.S. industrial competitiveness, promotes development of critical technologies, and increases development of technologies useful for private commercial and public sectors. Section 810 directs that DoD adopt streamlined procedures for acquisition of nondevelopmental items (NDIs). Section 821 requires that DoD (in its annual report to the Congress on critical technologies) identify each program element within the budget that supports development of one or more of these critical technologies, allocation of funds to individual technologies within that program element, and a comparison with allocation of funds in the previous year. Section 822 calls for the establishment of a Critical Technologies Institute as a Federally Funded Research and Development Center (FFRDC). Section 823 requires DoD, in consultation with the Departments of Commerce and Energy, and other federal agencies, develop a National Defense Manufacturing Technology Plan. These are be steps in the right direction; the challenge is to accept them as intended.

One key factor contributing to the erosion of the U.S. industrial base has been the adversarial relationship between DoD and contractors. To terminate this relationship, DoD must recognize it is right and proper for industry to make a reasonable profit on goods and services it sells to the government. On the other hand, industry needs an incentive to invest in high-technology equipment and associated facilities, but DoD cannot encourage American manufacturers to "overfacilitize." Without incentive, the industrial base will lose its drive.

Secretary Atwood believes the government must expedite the "transfer of leading edge technologies produced in our defense and national laboratories to United States industry." He believes "the DoD should develop policies that encourage competition among different technologies as well as among companies." If DoD follows these proposes, contractors treated fairly and offered proper incentives should generate the most value for their investment, improving the U.S. industrial base. In the past, the false competition factor (misuse of evaluation criteria in judging proposals) and misuse of second-sourcing (creation of competition for a relatively small production run and/or forcing facilitization of a second source for production quantities that do not justify such facilitizations) had a negative impact on the U.S. industrial base.

FINDINGS IN THREE RECENT STUDIES

• Harbor Research, Inc., Study

The American industrial base--including the defense industrial base just alluded to--is facing tremendous challenges that will result in major changes during this decade. This period will be critical to the overall development and survival of American industry.

According to Glen Allmendinger of Harbor Research, Inc.,[3] "The world manufacturing industry is beginning a decade of unprecedented competitive displacement, a decade that will require bold new business strategies." American manufacturers are no longer the world's technological leaders. Manufacturing competitiveness has its roots in management decision-making, philosophies, and biases. Competitiveness is not as deeply rooted in technology challenges, unfair competition, and blue-collar work rules. Allmendinger believes that overhead, slow decision-making, and separation of product and process design are symptoms of a "bureaucracy that is eating itself alive."

Let's consider results of a survey of 80 senior engineering, manufacturing, and operations managers conducted by Harbor Research. The survey determined that increasing product quality is the principal reason for automating; however, based on investment drivers, lowering manufacturing costs are usually easier to justify. See Figures 1 and 2. The close ranking of cost and quality indicates manufacturers understand that building the product right the first time lowers cost.

Harbor Research recommends radical strategy changes in six areas to reconcile manufacturing competitiveness with investment; namely, management approach, organizational structure, product realization and innovation, operations philosophy, automation technologies and investment, and education and training.

1. Management Approach. American management will have to develop real team approaches--tightly knit organizations that create responsiveness and company-wide ownership of ideas. Management will have to reduce key decision cycles by cutting extraneous levels and setting up new standards. Management will have to decentralize information flow. In this way the company will be able to process more information and make faster, and hopefully, better decisions.

2. Organizational Structure. "The move toward greater simplicity is a do-or-die necessity." Without structural flexibility, American industry will be unable to

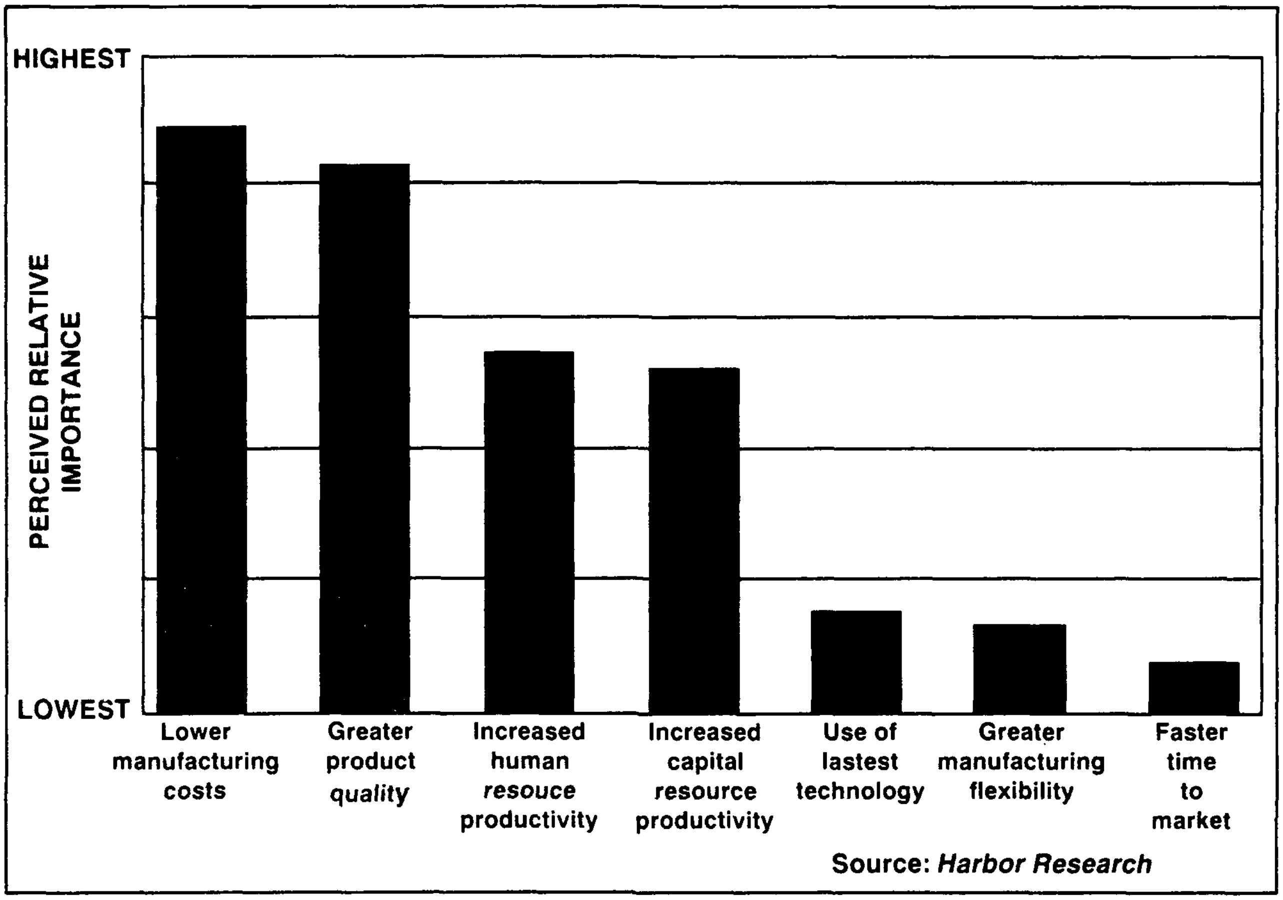

Figure 1. Investment Drivers

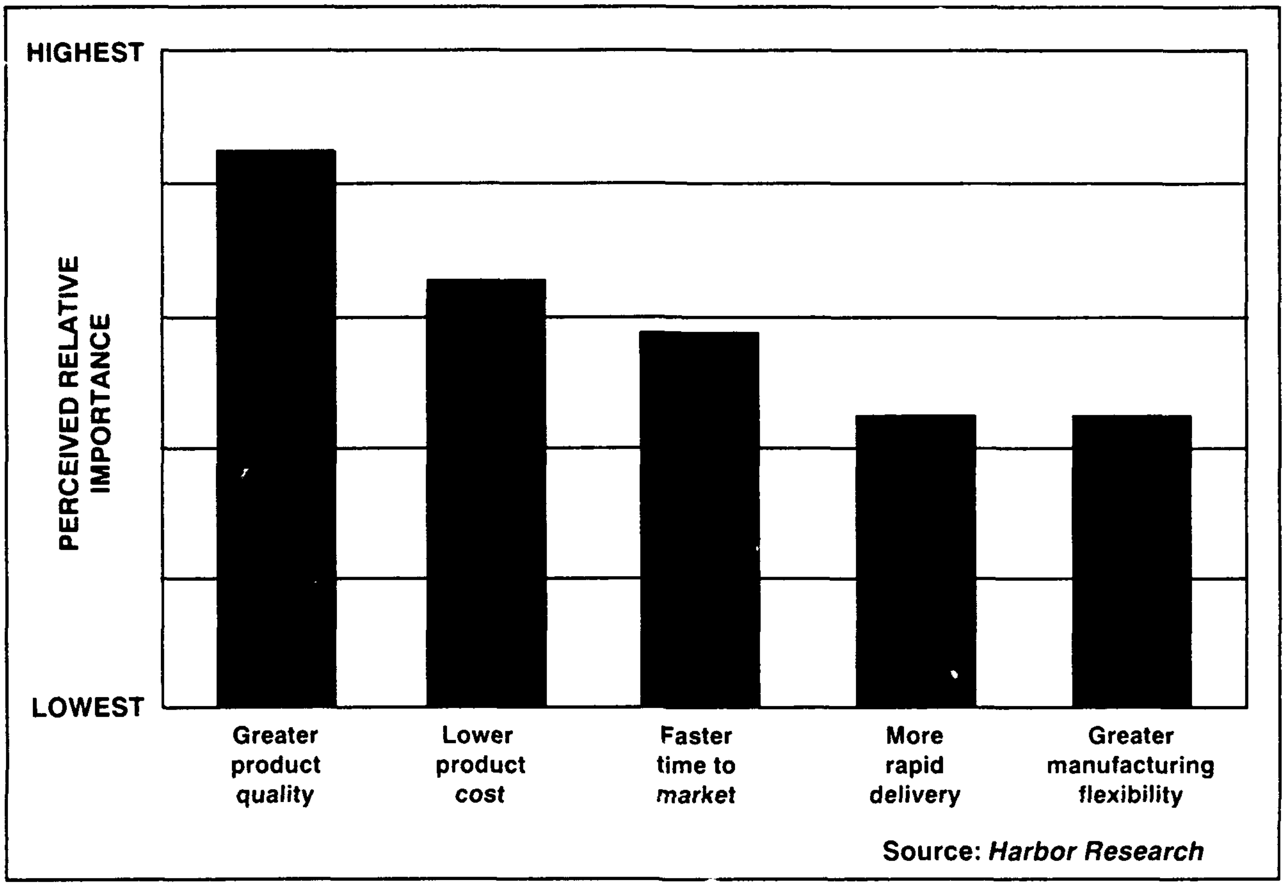

Figure 2. Competitiveness Drivers

respond to the global market's demand for innovative products and services. American companies will have to instigate *ad hoc* team approaches and develop multidisciplinary managers to survive.

3. Product Realization and Innovation. Offshore manufacturers are continuing to decrease turnaround, thus creating competitive advantages over American counterparts. American companies will have to integrate product specification and process design through a team-oriented approach.

4. Operations Philosophy. Current operations philosophies rely on outdated assumptions like high-volume and stable markets, stable product mixes, and stable currency. These assumptions have promoted rigid functional boundaries and management incentives based on span-of-control performance rather than on performance of the whole enterprise. The new philosophies American industry adopt must result in producing high quality goods at the lowest cost and with optimum long-range flexibility.

5. Automation Technologies and Investment. Past American manufacturing strategy presumed that continuous bandaging and minor improvements of facilities and processes would protect capital investment. Today, progressive American companies are investing in flexible, integrated technologies to broaden their range of products beyond those which a single facility or production line can build. Flexible automation is permitting them to reconfigure quickly and engage in lower profitable product runs.

6. Education and Training. Education and training in America are a must in the 1990s. The Harbor Research report notes, "In a period of rapid change, education becomes a critical success factor. If management and workers cannot find an effective way to apply new philosophies and automation tools, no amount of technology will solve the manufacturing challenge."

• Ernst and Young Study

According to results of a study by Ernst and Young[4] of 277 manufacturers located primarily in the Great Lakes area, 72 percent will hold but not improve their current competitive position. Seventeen percent will lose ground. It appears most of the companies are taking the necessary steps to improve.

Ernst and Young found that successful American manufacturers use the following common strategies:

Place decision-making authority at the operating level.
- Focus on quality improvement rather than on cost reduction (and achieve both).
- Invest significantly in human resource development and technology.
- Focus on planning processes including their internal organization and their external competition.
- Use operating measures extending beyond traditional manufacturing views.
- Offer broad product lines upgraded through continuous innovation and, thereby, gain a good reputation for products and services.
- Integrate vertically, become involved in international markets, and are less involved in markets where customer bargaining power is cause of change.

• **Deloitte & Touche Study**

According to the survey conducted by Deloitte & Touche[5] of 759 manufacturing executives, quality will be the critical factor for success in the 1990s, but it only will be the price of admission in the global market. Findings revealed that customer service will be a competitive battleground and American manufacturers must establish good customer service to gain a desirable edge.

Gregory M. Seal, a manufacturing consulting services partner at Deloitte & Touche, said service includes ease of product repair, pre-sales technical support, and after-sales support. Most survey respondents said they plan to improve their business infrastructures by making a strong commitment to human resources, vendor quality, labor/management relations, and worker safety. Less than 30 percent of respondents believe they are receiving significant benefits from investments in advanced technology. See Figure 3. Only 25 percent of the manufacturing executives surveyed said their companies were operating at state-of-the-art level in manufacturing technology.

IMPACT OF EUROPEAN ECONOMIC COMMUNITY

This paper would not be complete without comments on EC 92, which comprises 12 European countries planning to take 300 legislative actions to remove trade barriers and create an internal market by 1992. The European Community includes the United Kingdom, Germany, France, Belgium, Denmark, the Netherlands, Spain, Portugal, Italy, Greece, Luxembourg, and Ireland. The European countries of Austria, Finland, Iceland, Norway, Sweden and Switzerland did not join EC; they have been the European Free Trade Association for more than 25 years and prefer independence rather than alignment with the EC. They are receiving many EC benefits without incurring membership costs.

To date, only about half of the measures issued by the EC Council of Ministers to eliminate trade barriers and deal with regulations governing testing and certification of industrial products, agreements relating to patents, and a general system of mutual recognition of diplomas issued for higher education have been enacted. Areas of primary concern to the United States are the potential impact of the EC actions on standards, standards development and implementation, and procedures being written to test and certify regulated products marketed in Europe. Most observers agree that the EC will not wipe out cultural distinctions and the economic changes will not result in a United Europe similar to the United States.

One week before President George Bush met with European leaders in Paris in the fall of 1990 for the Conference on Security and Co-operation, he signed a statement aimed at formalizing ties between the United States and the EC. The statement called for more frequent meetings between United States officials and EC leaders. This appears to have been a wise move because business leaders on both sides of the Atlantic are taking a great interest in the developing community of European nations.

Many American small- and mid-size companies have been concerned about how foreign competition will affect their businesses. According to a survey by Peat Marwick in 1989, a majority of American companies will be "called to action" if companies in the EC become a more competitive force in the United States. American industry speculates that as companies in the EC nations grow stronger, they will compete in the U.S. market and have a direct impact on the American manufacturing community.

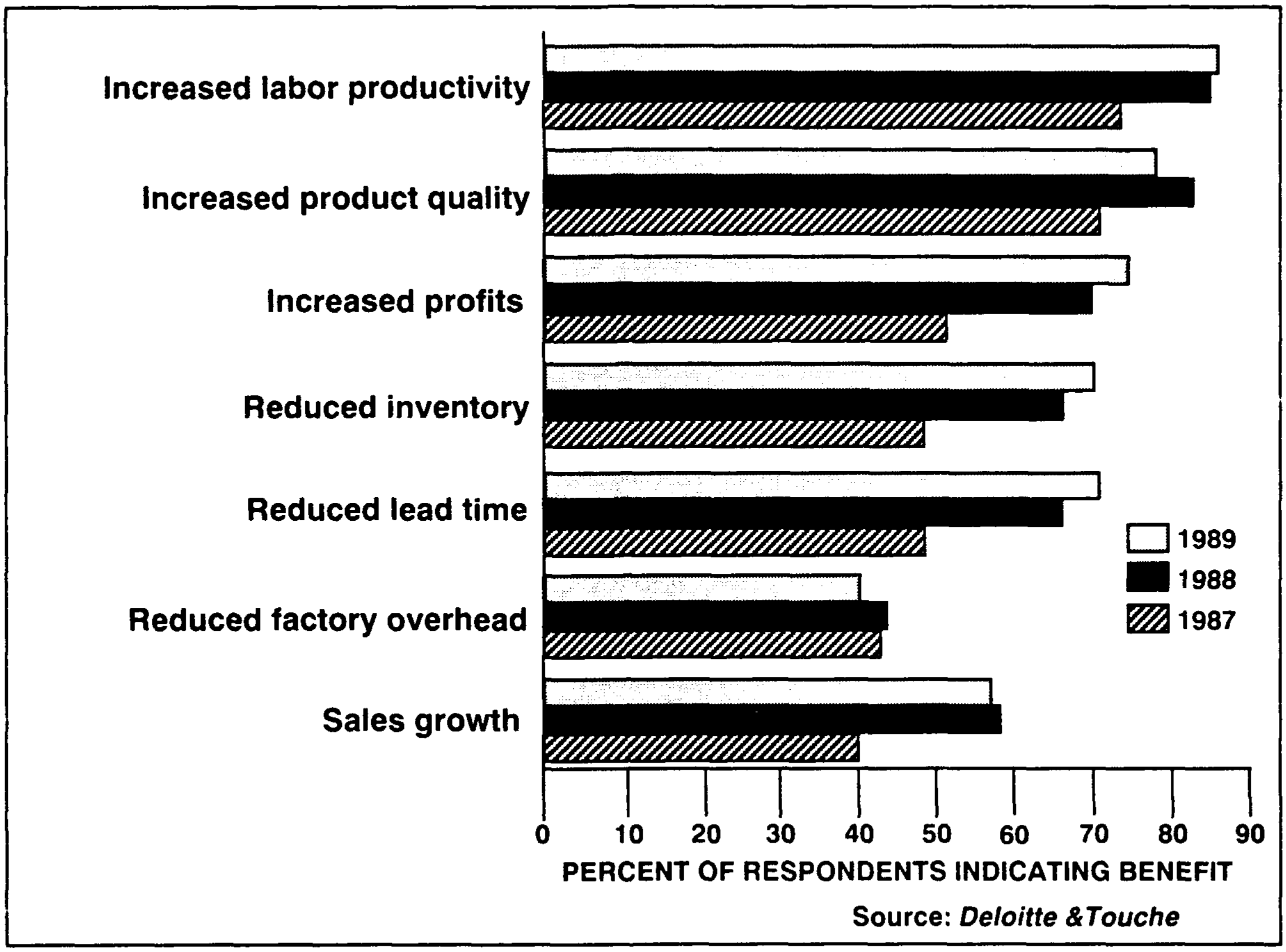

Figure 3. **Perceived Benefits of Technology**

To date, many small- and mid-size American companies have had mixed success in exporting products. On the other hand, many wholly owned subsidiaries or branches of multinational corporations have been successful. It appears that small- and mid-size American companies will have to develop offensive and defensive strategies to meet and survive this new competition. It is of paramount importance that these American companies learn quickly how they may be affected. Their continuing existence may depend on making informed decisions about whether or not to expand their market globally.

AMERICAN EDUCATION

Investment in education must become a national priority. One major cause of decline in our industrial and economic competitiveness is related to our educational system. Colby H. Chandler, believes the education gap between the United States and its competitors is alarming. He says "We are failing as a nation to provide this country with a properly educated workforce....[6] Our failure to provide manufacturing with an educated and skilled workforce may not seem serious today. However, the full extent of the problem will become evident when economic times get tough." It is his conviction that an extraordinary manufacturing capability is essential if we are to avoid massive dollar appreciation as the means to balance America's external accounts. A poorly educated workforce will undoubtedly keep our country from achieving that capability.

If America does not adequately educate engineers and technicians who will support advanced manufacturing requirements, our country will not be able to develop or maintain a world-class manufacturing environment. Deputy Secretary Atwood, recognizing this, said "The challenges in this area are enormous, but the opportunities are equally great."[7]

CLOSING THOUGHTS

American companies with the knowledge and experience required for survival of our industrial base--knowledge and experience that can't be duplicated easily by a foreign company--must concentrate on things they do best and team with other companies in their industry, or form joint ventures to remain competitive in today's global environment. The Congress must pay close attention to the erosion of the American industrial base. It may have to relieve some of the tax burden on American industry, the kind of burden not imposed on foreign firms selling products in the United States.

It would be appropriate for the Congress to establish incentives for long-term investment in modernizing our industrial base and technological development. While doing so, efforts of the Congress and the Executive Branch to strengthen the American industrial base should not be politicized.

I think that by the next century, there will be three highly competitive manufacturing and trading areas in the world; namely, the United States, the European Economic Community, and the Far East countries (often referred to as "Pacific Rim" countries). The Far East countries probably will be led by Japan. The great markets of the world will no longer be defined by national borders. Leaders in the global market will be what we refer to today as "world class" companies competitive internationally. To attain this status, these companies will have to set a reasonable price for products, offer high-quality products, and assure products are available on a timely basis.

In the final showdown, the deterrent strategy of the United States will depend on maintaining a healthy industrial base that is technically advanced, efficient, and flexible enough to respond to any crisis. In the United States of the future, joint ventures and mergers probably will gain greater importance than in the past. The new European Economic Community with 320 million people, the largest single market in the industrialized world, will probably provide challenges for American industry as should the Pacific Rim countries. There also will be new opportunities for growth and success in the world market.

Many people believe that today's developing country will be the manufacturing leader tomorrow. The question the United States must answer is: Do we have a national resolve to correct our mistakes and meet the challenges to be overcome before we can become a world-class technological and industrial leader? Without such a resolve, and a commitment to excellence, we may never regain the leadership we once held in the industrial world.

Paul Valery[8] said, "The trouble with our times is that the future is not what it used to be."

ENDNOTES:

1. Remarks by The Honorable Donald J. Atwood, Deputy Secretary of Defense, at the National Forum Foundation in Washington, DC, 6 November 1989.

2. Hal Sperlich, President of the Chrysler Corporation (1984-1988), and a 20-year employee with the Ford Motor Company.

3. Glen Allmendinger, President, Harbor Research, Inc., Boston, MA.

4. "The American Competitiveness Study," conducted by Ernst and Young, Cleveland, OH, 1990.

5. "Survey of North American Manufacturing Technology," conducted by Deloitte & Touche, Cleveland, OH, 1990.

6. Remarks by Colby H. Chandler, Chairman and Chief Executive Officer, Eastman Kodak Company, 1989.

7. Atwood.

8. Paul Valery (1871-1945). He succeeded to the chair of Anatole France at the French Academy.

THE ACQUISITION OF ADVANCED MANUFACTURING TECHNOLOGY

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ABSTRACT

Advanced manufacturing technologies, such as Computer-Integrated Manufacturing (CIM) and Flexible Manufacturing Systems (FMS), are perceived as panaceas for all that ails our industrial base. Unfortunately, these new technologies also bring a host of new problems for management. In the private sector, these problems complicate the contracting and capital planning processes. In the defense sector the problems are further exacerbated. This article identifies several contracting issues associated with the acquisition of advanced manufacturing technology. It will also identify several obstacles which are prevalent in the defense contracting environment. Finally, this article concludes that future modernization efforts must address all of the barriers which hamper the acquisition of advanced manufacturing technology.

INTRODUCTION

American industry has found that the much ballyhooed advances in manufacturing technology are accompanied with major obstacles during implementation. Managerial focus on short-term profits is a familiar deterrent to capital investment and long term planning. There are, however, several new deterrents associated with advanced manufacturing technology. These problems are compounded for defense contractors, who face the additional hurdles of funding uncertainties, a DoD cost-based profit policy, and possible program termination. Future policy on capital investment in technology modernization programs should address both the DoD and non-DoD barriers.

MANUFACTURING TECHNOLOGY IN THE PRIVATE SECTOR

American manufacturing firms must improve the process of implementing manufacturing technology in order to remain globally competitive in the 1990s. American industry must progress from the traditional stand alone machine production approach to a total systems approach. A systems approach may well integrate several of the following current generation technologies:

1. Computer-Aided Design/Computer Aided Manufacturing (CAD/CAM),

2. Flexible Manufacturing Systems (FMS),

3. Robotics,

4. Optimized Production Technology (OPT), and

5. Computer-Integrated Manufacturing (CIM).

There are many advantages attributed to these various manufacturing technologies to include: more efficient use of capital equipment, increased productivity and flexibility, and improved quality. Also, these technologies have reduced: work in process, direct labor costs, floor space, scrap, and rework.

Despite all of these benefits, actual implementation of complex manufacturing systems has been limited due to the accompanying high levels of risk and capital investment associated with these high technology acquisitions.

CONTRACTING ISSUES

A firm contemplating new manufacturing technologies, will find the acquisition of these systems will require a marked departure from traditional contracting approaches. The firm is no longer simply buying a new machine that is more efficient than the one it replaces. The objective is now to buy a synergistic capability. Traditional day-to-day contracting practices do not prepare organizations for one-time, strategically important acquisitions. This type of buying is complicated by:

1. Its long duration,
2. High cost, and
3. Extensive integration requirements.

The contracting and capital planning process for these new technologies is complicated by the following:

1. This may be the most expensive capital equipment purchase ever made by the firm.

2. The future existence of the firm may well depend on purchasing the right system.

3. This will be a "one-time," as opposed to a piece-meal buy.

4. The acquisition time frame is exceedingly long. Successful FMS systems in the United States take two and a half to three years to conceive, develop, acquire, install, shake-down, and finally get running [3].

5. Past contracting experience may provide little guidance for a one-time, large and technologically complex system acquisition.

6. These new systems will require extensive employee training. This typically results in a an organizational or "culture" change.

7. The requirements for each company are unique. Consequently, there is no "total" system that can be bought off-the-shelf, plugged in, and switched on [4].

8. Senior management should be actively involved in the process, but probably won't be. At a time when industry demands a keen managerial (or strategic) insight into the manufacturing operations, most CEOs and board members come from financial, legal, or marketing backgrounds [5].

Due to the strategic importance of these new technologies, a dedicated planning team with diverse experience in engineering, manufacturing, information systems,

and contracting will be necessary.
Although senior management should be an active player, this may prove impractical. "Ironically, while senior management recognizes the need, many people at high levels don't have much stomach for extensive planning. They know they should be doing it, but they want to minimize the time it takes" [6].

ACQUISITION ISSUES

The following are a number of issues that should be addressed in the successful acquisition of advanced manufacturing technologies:

1. There is a tendency to overemphasize the technical aspects to the exclusion of people-oriented and communication issues. For example, the problems associated with CIM implementation are 80% people related and only 20% technological [6].

2. A tendency towards naivety among managers and engineers in their apparent belief that the task is relatively simple and all that is needed is money and a hardware vendor.

3. Managers tend to underestimate both the extent and the cost of planning needed. The Japanese will typically spend 100,000 hours over a two year time frame to plan for an FMS system composed of 18 machines [4].

4. Peripheral fixtures and tooling can cost as much as the hardware itself [4].

5. The more advanced systems cannot work efficiently unless they are linked directly to order entry, sales forecasting, and contracting.

6. The firm must clearly know its requirements before it becomes locked in with an equipment supplier. Otherwise, the buying firm could, by default, become the victim of the vendor's overly enthusiastic objectives.

7. Due to the extreme capital investment required and the risk associated with these new technologies, many firms are pursuing a piecemeal acquisition approach. While this is not recommended, a firm should only buy a partial system (i.e. CAD only) after it has planned for the total system [4].

8. In addition to performance specifications, the buying firm should also have interface specifications.

9. Finally, the buying firm should reappraise potential costs before finally placing orders. The assumptions made in the early planning stages may no longer be valid.

DOD OBSTACLES

Defense contractors face the same obstacles in implementing advanced manufacturing technology as their fellow non-DoD companies. However, they face the additional obstacles of:

1. Funding uncertainties that result from such practices as incremental funding and annual budgeting exercises.

2. A cost-based profit policy. The highly efficient contractor that significantly reduces costs through advanced manufacturing technologies could suffer lost earnings due to a reduced cost base [7].

3. Possible program termination as a result of changing threats and budget limitations.

4. Undermining legislative initiatives. Both legislative and administrative actions have provided additional disincentives for capital investments. Dr. Waelchli has stated: "These actions have simultaneously raised defense contractors' risks and lowered their prospective rewards so that risk adjusted returns on assets invested in the defense industry are no longer competitive with the range of returns available to capital invested elsewhere [8]."

Waelchli cited a number of studies to support the above statement. For example, the Defense Industry Advisory Group Report stated:

"Current policies discourage investment in technology and productivity."

The MAC Report on The Impact on Defense Industrial Capability of Changes in Procurement and Tax Policy stated:

"As companies feel the squeeze on available capital they will be forced to:

- Reduce risk by opting for low technology alternatives.

- Reduce investment needed for productivity enhancement and modernization."

Based on these reports, Waelchi concluded: "The domestic defense industry is no longer an attractive investment; reward no longer compensates adequately for risk, and capital is fleeing."

DOD CAPITAL INVESTMENT INITIATIVES

The Defense Department has implemented a number of initiatives over the past 20 years to help alleviate many of the DoD unique disincentives to capital investment. The most notable initiative is the Industrial Modernization Incentives Program (IMIP). "IMIP is a joint venture of government and industry designed to accelerate the implementation of modern equipment and management techniques in the industrial base. These programs are implemented when competitive market forces are insufficient to bolster independent contractor modernization. They are also used when significant benefits such as cost reduction, elimination of production bottlenecks, improved quality and reliability, and improved surge capability can be expected to accrue to the government [9]." In the USAF Aeronautical Systems Division alone, almost $1.6 billion was committed through FY89. Estimated savings from these investments exceed $3 billion over the next decade [10]. Clearly, IMIP successes illustrate the current problems are not insurmountable. Through teamwork, initiative and an integrated management approach, government and industry can make significant progress in overcoming the barriers to advances in manufacturing.

CONCLUSION

Existing and future technology modernization programs must address all of the disincentives to capital investment, not just those that are DoD unique. The government barriers are not simply a "delta" difference above those found in commercial industry. Frequently, DoD obstacles only compound those barriers that already exist in the private sector.

To maintain a competitive defense industrial base, it is imperative that future modernization policy address all of the barriers (both DoD and non-DoD) that hamper the acquisition of advanced manufacturing technology.

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INTERNATIONAL ASPECTS
of ACQUISITION

EUROPE 1992 CATALYST FOR CHANGE IN DEFENSE ACQUISITION

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"The trouble with the future is that it usually arrives before we are ready for it."

-- Arnold H. Glasgow

ABSTRACT

Although the European Community's Europe 1992 program is not designed directly to impact defense it will nevertheless result in profound and subtle effects on U.S. and European defense acquisition communities. Europe 1992 infrastructure improvements, when combined with a parallel drive toward integrated European armaments markets and a restructuring European defense industry, both encouraged in part by Europe 1992, should result in a stronger, more self-reliant European defense acquisition community. These changes may well result in a loss of U.S. defense industry competitiveness, lowered U.S. defense sales to Europe, a reduction in transatlantic cooperative programs, and an increase in unit costs of U.S. defense items. This study examines such issues and recommends changes to the DOD and U.S. defense industry to reduce potential impacts on the U.S. defense acquisition community.

INTRODUCTION

The European Community and Europe 1992

The European Community's four executive institutions-- Commission, Parliament, Council of Ministers and Court of Justice--form the institutional framework for constructing an economically united Europe. Referred to collectively as the EC, these executive institutions represent the 12 member countries of: Belgium, Denmark, the Federal Republic of Germany, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom.

In its present day configuration, the EC has evolved considerably since its inception after World War II. In 1957, the Treaty of Rome was signed to create a single European market (Common Market) by eliminating trade barriers which impeded free flow of goods, people, services and capital among member states. This objective went largely unrealized as each country's nationalistic approach tended to develop and favor differences between member states rather than harmonization and integration of national markets. European industry **fragmentation, inefficiency and overcapacity resulted,** preventing Europe from realizing its full potential as the world's largest trading block. Benefits being lost by not completely integrating Europe's markets have been estimated and include creation of 2-5 million jobs, an EC gross domestic product increase of 7 percent during a 5-year period beginning in 1987, and a 6 percent reduction in overall consumer prices.

In 1985, the European Commission published its now famous white paper outlining a plan of action and milestones to complete integration of Europe's national markets. It proposed implementation of **279 directives to eliminate barriers to free trade among the member states.** The paper called for approval and adoption of all 279 directives by the Council of Ministers by December 31, 1992; hence, Europe 1992. The concept was formalized in 1986 when Member Heads of State signed the Single European Act (SEA). The SEA contains provisions to restructure and accelerate the EC decision-making process regarding most proposed directives. With the SEA in effect, the Council of Ministers now have political authority to adopt directives through a qualified majority vote vice unanimity that was required in the past and attributed with lack of progress. The SEA also contains a provision calling for increased coordination of "economic and political aspects of security." This provision opens the door for the EC to play a greater role in this area by increasing its influence in European security dialogues.

As of the last official report in June 1989, **50 percent of the 279 directives were adopted** by the Council of Ministers. Excellent progress has been made in liberalizing finance regulations and business law associated with mergers and acquisitions, creating a powerful and supportive environment for industry-wide consolidations presently underway. However, limited progress has been made in three crucial sectors considered keys to total success of Europe 1992: taxes, labor and national public ocurement. Unanimous voting is still required for most issues in these areas because they are considered essential to preserving a country's national sovereignty. Many observers believe such national sovereignty problems could prevent the program from reaching its goal of passing all directives by December 31, 1992.

Despite lack of progress in these areas, Europe 1992 enjoys enormous credibility and high expectations within Europe's private sector. As a result, European **industries are proceeding with consolidation and restructuring as if the Europe 1992 program were already in effect.** This movement by industry will create a political and economic environment within Europe that will not only encourage the passing of the remaining directives, but **will compel Eurocrats to complete the effort.** Restructured industries and their workers are not likely to stand by patiently and await passage of the remaining directives while the clock is ticking on receiving returns on investments associated with restructuring. Such internal political pressure, combined with growing competitiveness of industries outside Europe, should help push the Europe 1992 movement toward a successful conclusion, despite delays caused by national sovereignty issues. For these, and other reasons, Europe 1992 must be looked upon as a **continuing movement whose time has come,** rather than as a specific date on the calendar.

The Changing European Armaments Market

As the European Community goes about creating more open commercial markets, sister movements on the demand side of the European defense market are gathering strength and ideas from Europe 1992 and marching toward similar changes in the European armaments markets. The Independent European Program Group (IEPG), representing all NATO European nations, except Iceland, is chipping away at protectionist walls between national defense markets and working toward coordinated European defense research and cooperative European development programs. Despite problems such as national security concerns, lack of a formal treaty, and a controversial plan for dividing up nations' shares of defense business through a vague concept called *Juste Retour*, the IEPG continues to make progress.

Meanwhile, the NATO Conventional Armaments Planning System (CAPS), in an exercise of partial duplication, is working toward similar goals by matching national requirements with NATO force requirements and promoting NATO cooperative programs. Not to be left out, a rejuvenated Western European Union is beginning to assert itself as a unifying force with concerns about pan-European and transatlantic armaments cooperation. Combined in a process that some call "parallel integration," the Europe 1992 movement and the IEPG are **working toward a more united and self reliant European acquisition community with open defense markets.** When formed, this reconstructed European acquisition community should be capable of dealing with the U.S. acquisition community on a more equal basis.

European Defense Industries Restructure: U.S. Counterparts React

Throughout the European defense industry, massive restructuring, driven by overcapacity and declining defense budgets, is occurring at company and industry levels through establishment of **long-term** strategic alliances (mergers and acquisitions). This restructuring is aimed at increasing an individual company's size, core capability and product mix, while achieving the critical mass necessary for world competition at industry-level through teaming and consortia.

As Europe's defense firms go through this restructuring, the Europe 1992 program is giving them a shot in the arm by creating efficiencies in Europe's infrastructures that will translate directly into improved defense industries. Examples include (1) implementation of the Single Administrative Document (SAD) which should significantly reduce costs associated with cross-border movement of defense goods and equipment; (2) mutual recognition of diplomas and professional degrees of defense workers; (3) deregulation of utilities which should increase competition and provide cheaper energy to heavy users in defense manufacturing; (4) creation of common, harmonized industrial standards which should improve the efficiencies of the european defense industry; and (5) gradual shifting of antitrust oversight from national to EC control which will contribute to defense industry consolidation and rationalization. In addition, Europe, unlike the United States, has taken its research and development concept a step further by establishing and funding ($5.2 billion) coordinated research programs for critical dual-usa technologies that will directly benefit the European defense technology base. These Europe 1992 improvements, when combined with aforementioned co-movement efforts to integrate the European defense markets and a restructured European defense industry with fewer but larger defense firms, should result in **stronger, more formidable competitors** for U.S. defense firms.

Just as Europe's new commercial industries can be expected to push the European Community toward a successful opening of commercial markets, restructured European defense firms can be expected to pressure the IEPG to complete the process of opening Europe's defense markets. Likewise, restructuring of the European defense industry into fewer but larger national defense firms is expected to create monopolies eventually, or near monopolies, in single nation's defense markets, providing **additional pressure to governments to integrate European defense markets** to maintain the benefits of competition.

Meanwhile, the U.S. defense industry is undergoing a tremendous self-education process concerning these changes in Europe. United States defense firms are evaluating market opportunities in Europe, and most major defense contractors are developing strategies to preserve world market shares in light of declining defense budgets and the new challenge from Europe. Strategic alliances with European defense firms are increasing but, for the most part, they are **short-term** project specific alliances that dissolve when the project ends. Establishment of long-term European alliances (cross shareholdings, joint companies, etc.) by U.S. firms is not likely at this time because of U.S. defense firms' high debt to equity ratios, declining European defense budgets, overcapacity in the European defense industry and U.S. firms' preoccupation with short-term financial results. In addition, restrictive U.S. policies associated with technology transfer and re-export licensing create a disincentive to U.S. firms considering long-term investments in the European defense market. These defense restrictions also make U.S. defense firms a less attractive partner from the European perspective.

Implications for U.S. Acquisition Community

European industry and government executives interviewed felt strongly that future partnerships with the United States must involve equal relationships. Europeans now want to be true partners, not just customers. This attitude is contributing to a strengthening trend within Europe for pan-European solutions to armaments. Encouraged by outdated U.S. policies and approaches to cooperative programs, and non-existent, high-level DOD advocacy and oversight for cooperative programs, this trend could result in a polarization of U.S. and European acquisition communities. As a result, **pan-European, vice transatlantic defense programs,** will probably be favored by Europeans as they form their new defense acquisition community. At a time when the usefulness of NATO is being questioned and the United States is growing ever more concerned with a Europe that seems determined to go its own way, this trend should be countered with U.S. policies and relationships that pull Europeans into a closer relationship rather than policies that push them away.

The revitalized and more competitive European defense industry will likely produce a larger share of Europe's defense armament requirements. Political and economic pressures to do so will be considerable as Europeans seek so reap the benefits of their restructuring. This will most likely result in a loss of U.S. defense sales to Europe. Also, stronger, more competitive European defense firms with fewer export restrictions and long-term experience in export sales will be positioned better to exploit and penetrate Third World defense markets. Together, potential implications to the U.S. defense acquisition community are considerable, including reduced exports, with a concomitant **increase in unit costs** calculated at approximately 2.6 percent for U.S.-built equipment in 1992.

RECOMMENDATIONS

It is clear that the ongoing changes in Europe will have profound effects on the U.S. defense acquisition community ranging from reduced defense exports to fewer transatlantic cooperative programs. The DOD can lessen the impact of these changes by supplementing its current armaments cooperation structure with appropriate high-level advocacy and oversight. In addition, the DOD should review its current organization and policies for international armaments cooperation and trade to meet future relationships with a strengthened European acquisition community. Furthermore, DOD can send a strong and timely signal to Europe that it is serious about maintaining transatlantic relationships in armaments collaboration by implementing the following recommendations.

(1). **Update DOD armaments cooperation goals** through a Secretary of Defense letter. The letter should replace and update the 1985 armaments cooperation letter issued by Secretary Caspar Weinberger and include DOD's approach to non NATO, Nunn initiative programs and NATO CAPS. The letter should also include direction to reestablish the Defense Cooperative Working Group and the establishment of an *ad hoc* Defense Cooperative Action Group.

(2). **Reestablish the Defense Cooperative Working Group (DCWG).** The group should be chaired by the Deputy Secretary of Defense for the first 6 months, thereafter by the Under Secretary of Defense for Acquisition, and provide the necessary advocacy coordination and oversight for DOD armaments cooperation and trade, resolve interdepartmental conflicts concerning technology transfer, re export sales, and export licenses.

(3). **Establish optimal DOD organization and policies for defense cooperation and trade** through an *ad hoc* DOD Cooperative Action Group which would recommend changes to the Secretary.

(4). **Increase DOD wide education on international aspects of program management** through the Defense Systems Management College. This increase in education should concentrate on functional area training in contraction, cost accounting, etc.

(5). **Work through the NATO Conference of National Armaments Directors (CNAD) to ensure changes in the European acquisition community are not detrimental to transatlantic armaments cooperation and trade.** The CNAD should be encouraged to work toward open defense markets NATO wide and to increase efforts toward ensuring the success of the Nato Conventional Armaments Planning System.

Parallel to these DOD actions:
(6). **The U.S. defense industry should develop appropriate strategies to establish and maintain strategic alliances with the European defense industry.** Industrial alliances within Europe are developing quickly, and U.S. defense firms without established transatlantic alliances may find it difficult to be involved in future European defense business.

RATIONALIZATION, STANDARDIZATION
& INTEROPERABILITY
REVISITED

James H. Gill
Ballistic Missile Organization

ABSTRACT

The military necessity for RSI increases as the possibility of a non-nuclear European war increases. U.S. force sizing is an issue of concern to the new administration as it wrestles with the burgeoning U.S. deficit. There is a growing movement within the U.S. defense community toward the implementation of significant cuts in U.S. forces in Europe. In this environment there is a critical need for innovative use of force multipliers and synergistic enhancements.

RSI is a relatively inexpensive means of enhancing force capabilities without a corresponding increase in cost. It represents the traditional "more bang for the buck" philosophy that is crucial during times of budgetary shortfall.

Unfortunately, within the Atlantic Alliance RSI is a potentially explosive political issue. The creation of an interdependent European community in 1992 has brought forth a number of economic issues which are contentious in nature, not the least of which is the matter of RSI.

In order for RSI to be an effective force multiplier, a certain amount of altruism must exist between the partners. One country must be willing to sacrifice the interests of some segments of their defense community in order that there is a consistency of hardware and equipment. It is mandatory that both (all) parties adhere to the principal of the "two-way street" in order to ensure that neither party is asked to assume an unfair share of the burden.

This paper will evaluate the success (or failure) of RSI to live up to its initial promise. It will examine an example where RSI proved successful, as well as one in which success has proven elusive. It will discuss the elements contributing to success and those which produced failure. Finally, the paper will present arguments as to the viability of the RSI program in the evolving NATO environment.

INTRODUCTION

The NATO Alliance is currently undergoing dramatic and far-reaching changes. Events in the Soviet Union and Warsaw Pact nations have created an environment of expectation in Western Europe. Recent demonstrations of democratic reform in the east have led to demands in the west toward a more conciliatory posture on the part of the U.S. and its NATO allies. Internal political pressures have forced the postponement (abandonment?) of NATO plans to upgrade short-range nuclear forces (SNF).

An ancillary development has been the movement toward consolidation (political and economic) of the European Community. This has created a concern on the part of U.S. policymakers, as well as the U.S. business community, that Europe is effectively disengaging itself from the U.S. sphere of influence. There are numerous ramifications to this movement. From the economic perspective, U.S. industries (both defense related and not) are concerned that they will be prevented from competing for sales within the new Europe. Defense industries are concerned that they will be excluded from competition for the replacement and modernization of weapon systems that are used by the NATO forces. On the political side, there is fear that Europe, in its quest for reuniting east and west, will effectively neutralize itself in the east-west competition. The very basis of competition has seen dramatic changes during the past 15 months. The fragmentation of the Warsaw Pact, along with the nationalistic stirring within the Soviet Union call into doubt the very basis for the existence of NATO and the Western Alliance. The significant reductions in U.S. and Soviet forces in the European theater merely serve to highlight the acceleration of change and the need to maintain a flexible approach to the role of NATO in this turbulent environment. Traditional policy concepts no longer serve the U.S.' interests. If NATO is to remain a viable and credible organization, it will have to adapt to this new and dynamic situation.

In this turbulent environment the matter of Rationalization, Standardization and Interoperability is a relatively minor issue. It is however a very great concern to those in the U.S. defense community who believe that the integration of different weapons in an ever shrinking universe of weapons and soldiers is a major strategic issue. In a time of dwindling resources, the inability of NATO to maximize its force multipliers may significantly weaken the ability of the Western Alliance to respond to any future Soviet aggression or political intimidation. While there are some who believe that the Soviets no longer pose a credible threat to U.S. and European interests, it appears incredibly short sighted to ignore the potential for a reversal in Soviet behavior based upon their potentially catastrophic economy. If bread lines drive the Soviets into the streets, it is not unreasonable to predict a more belligerent trend in their foreign policy (if not from Mister Gorbechov, perhaps from his successor). It seems only reasonable, given the significant changes experienced during the recent months, to allow the international environment to stabilize before adapting policies that will be difficult to reverse once they are initiated. To this end, RSI represents a reasonable approach to maintaining the NATO deterrent, given the ever shrinking resource base.

The history of RSI will vary by perspective. For the most part, Europeans have not been convinced that the two-way-street is anything other than a slogan that has been created to pacify the concerns of those in the European business community who believe that defense business for NATO is essentially a one-way-street. While it is true that there has been some improvement in the amount of defense business that has gone to European defense companies over the last few years, there is still a residual belief that these companies are not given equal treatment when competing for NATO business.

American companies, and politicians, are more likely to respond that American quality and reliability is the primary driver as to the reason that NATO has acquired predominantly U.S. weapon systems i.e. that the U.S. simply builds better weapons at a more reasonable price. If this dialogue sounds suspiciously like the ongoing debate between the U.S. and Japanese business communities it is appropriately so. Japanese businesses stress the quality and reliability of their products when defending allegations of unfair trade practices. U.S. businesses complain about unfair trade practices and an exclusionary market.

Some analysts believe that the advent of the new European Community will provide European defense companies with additional leverage in their competition with the U.S. for NATO weapons contracts. If the consolidation of the European community results in a monolithic trade partner, then there is a real concern that isolationist groups within the U.S. will take this opportunity to advocate a significant reduction in the American presence in NATO. The enormous budget deficit in the U.S. has led to a situation where European allies are preaching the gospel of fiscal restraint. Some politicians have already fixed upon the potential for reducing U.S. expenditures on NATO troops and weapons. If U.S. companies are excluded from competition for NATO weapon systems, then it is possible that, given the ever increasing Savings and Loan scandal, there will be a groundswell of public support for a reduction in U.S. expenditures to defend an unappreciative group of fair-weather friends.

If we are at a portentous turning point in the long-standing, and effective relationship between the members of the Western Alliance, what are some of the actions that prudent and responsible statesmen should be doing to ensure that changes to this relationship are as relatively insignificant as possible?

This paper will discuss the history of the RSI relationship between the U.S. and European partners. It will focus on the main elements of the upcoming European unification from a NATO perspective. And finally, it will recommend some actions that need to be accomplished at this time, to ensure that American interests are protected both in the long and short term.

TEXT

What exactly is meant by the term RSI? In short, this term has been used to describe the actions that must be taken to ensure that weapons that are used by NATO troops will be interoperable or, at least, compatible. That bullets manufactured in Britain will be adaptable to guns that are manufactured in West Germany. I provided a more complete definition of the elements of RSI in my article for the 1983 Federal Acquisition Research Symposium. To recap - the term Rationalization is perhaps the most difficult to define. Simply put, it is the attempt at making the most out of that which you already have. It is similar to the wise shopper, purchasing those items which will yield the maximum return on investment.

Rationalization may take the form of any of a number of guises. It applies to both weapons and non-weapons (personnel, resource management, communications etc.). It may be said that the derivation of the meaning lies within the word itself, that is, the rational application of resource management to maximize the effectiveness and minimize the expense. It is a broad term which encompasses both Standardization and Interoperability. An example in the present DoD environment would be the utilization of Total Quality Management (TQM). TQM symbolizes the attempt to do more with less, i.e. enhance productivity while simultaneously minimizing cost. It would seem that inasmuch as NATO faces many of the same circumstances that have created an environment that is favorable to TQM in the DoD, dwindling resources, a shrinking consensus to the need for the current level of security (due to the Gorbachev factor), TQM would seem to be an idea whose time has come.

A more realistic degree of multinational standardization of defense material within NATO can be achieved if adequate engineering effort is provided during weapon systems design and development to ensure maximum use of appropriate physical/functional interface standards for the pieceparts, components, subassemblies, and/or subsystems employed in the weapon system. With appropriately engineered interface standards, a weapon system (including components and subsystems) designed and produced in one nation, may not be 100 per cent the "same" (iden-tical) as a similar-purpose weapon system designed and produced in another nation; but, both systems (and components thereof) will be adequately interoperable when deployed in any joint defense operation. This standardized-interface approach facilitates equitable, shared production amongst the participating nations and, at the same time, reduces the duplication of development costs and enhances logistics intersupportability for all user nations.

Interoperability represents the most logical level of standardization. It merely presumes that weapons of one country will operate in a supportive manner with those systems of other countries. Thus, a German tank would continue to operate while utilizing British fuel, ammunition or communications equipment. Interoperability, while falling somewhat short of the optimum level of standardization, offers the flexibility needed to ensure logistical and operational continuity, i.e., the tanks will continue to function. In light of the move toward a consolidated Europe, perhaps the bickering and competitiveness that frustrated many of the previous efforts at standardization will be eliminated. This could auger well for future attempts at this type of RSI. While the U.S. may have to reconcile itself to a smaller piece of the standardized pie, the Alliance would be better off for an increase in the standardization of NATO weapons.

The basic premise behind the concept of RSI is almost too good to be true. It is also almost so self-evident that it is hard to appreciate the difficulty of incorporating the concept into reality. How can any rational strategic planner be against the maximization of resource capability? It is only when subjected to the harsh light of political reality that the contradictions regarding RSI begin to surface. The economic competition between erstwhile allies must often be accommodated to the security needs of the Western Alliance. Thus, while NATO may have been originally intended as significantly more than merely a security alliance, there is a feeling that it has never quite matured into the more generic treaty organization that was once contemplated. The current peace initiative that has been launched by the Soviet Union has brought into focus some of the more vulnerable aspects of the alliance. It has also brought into focus new opportunities for improving or expanding the alliance and the benefits to be derived.

NATO is faced with three major issues. These issues are: burden sharing, conventional and nuclear disarmament (or at least force reduction) and the development of the European Community. First, the matter of burden sharing. This issue has been a concern since the late 1970's, as the European members have become more economically secure and able to contribute a greater share toward their common defense. This issue has been a focus of congressional attempts to reduce the level of U.S. troops stationed in Europe. These troops have previously been viewed as the trip wire that would ensure the participation of the U.S. in any major Soviet invasion of Europe. Previous discussions regarding the reduction of these forces had been seen as an attempt by the U.S. to decouple itself from involvement in a land war in Western Europe. In the current political environment it merely seems like a reasonable, fiscal policy. The burden sharing issue relates to RSI in that the Europeans often see the standardization issue as one in which the U.S. has forced them to contribute toward the purchase of "made in U.S." weapons. This has created a disenchantment with the amount of U.S. investment in the defense of our economic competitors.

National Security may be viewed in terms of capability and credibility. If a nation has no capability, the credibility of its proposed actions is not significant. NATO was founded upon the basic premise that the synergistic sum is greater than its individual parts. The viability of NATO ultimately must depend upon the collective sacrifice and contribution of individual states toward the greater good of the organization. Three factors enter into this decision. These are identified by Hans Morgenthau in his definitive work Politics Among Nations: "This interplay between a common supernational interest, separate national interests, and American power will determine whether or not NATO will accomplish what it has set out to do."[1]

The factors that Morgenthau describe are rapidly eroding, or at very best evolving into alternative scenarios. The common supernational interest is deteriorating as the economic competition between the U.S. and its Alliance partners escalates. The separate national interests include unification of Germany in conjunction with that of the other members of the European Community. These concerns, which are central to the European's perception of their changing political environment, have created the dual potential for either a closer coordination or some conflict between the U.S. and the other members of the Alliance.

And finally, the American power has a credibility problem. With each new initiative by the Soviet Union, the general population (both of Europe and the U.S.) becomes more inured to the idea that the Cold War is over. This means that there is significant resistance to the upgrade or replacement of "obsolete weapons".

In this light, RSI assumes an even more critical role in the ability of the Alliance to fulfill its basic mission i.e. the security of the Western European members of NATO and the associated national interests of the U.S. and Canada.

In my article for the 1983 Federal Acquisition Symposium, I spoke of the ongoing debate over the relative nature of individual nations contributions to NATO. "The current dialogue over contribution to the NATO force loading is an ongoing issue. While there is significant disagreement relative to the allocation of obligation, there is a fundamental agreement that a significant Soviet buildup must be countered by a similar NATO increase in capabili :." At that time the debate focused upon the appropriate response to the Soviet escalation of IRBM systems in the European theatre. The level and type of response was much discussed, however, a consensus agreed that an appropriate response was in order.

Today, the debate concerns disarmament, rather than increased armament. The Soviet's are presenting a "reasonable" approach to East-West relations. While this fact may be quite different, it represents an even greater risk to the security of the NATO Allies. With a reduction in the nuclear forces comes a greater reliance upon the conventional force capability. The Soviets also appear to be moving toward agreements in this arena as well, although it appears that the agreement is not as certain as once thought. As conventional forces are indeed reduced, the impact of the remaining forces becomes critical. RSI must be a factor in the negotiation of weapons reduction. The weapons that remain after completion of negotiation will have to accommodate a more varied set of responsibilities regarding the multiple options that exist for Soviet adventurism. While today's leaders in the Soviet Union may appear to be more concerned with Glasnost and Perestroika, there is no guarantee that the next group will be as accommodating. A prudent, cautious response will help protect the Alliance from the onerous responsibility of responding to a chill in the East-West environment with a deployment of additional weapon systems. The RSI aspects must be addressed by those security planners who are tasked with the maintenance of the credibility of the NATO deterrent.

> "Achieving American and allied defense goals depends upon enhancing cooperation and ending duplication. We can't afford to waste resources. This can be achieved only through a common desire to share and work together to maximize the 'value added' of weapon systems in the nations in which they are produced and by eliminating barriers to the cooperative development of common systems. In the past, lack of cooperation among NATO nations resulted in wasteful, simultaneous duplication, including the development of six types of main battle tanks, six types of fighter aircraft, and a plethora of antitank missiles and armored vehicles. More recently, the allied nations have reasserted the need for armaments cooperation and reaffirmed their commitment to rationalization, standardization and interoperability"[2]

While it may require the optimism of a political Pollyanna to suggest that the sovereign nations of the Western Alliance could be persuaded to accept RSI to the exclusion of their own defense industries, it does seem that there have been a number of options for RSI that have not been effectively implemented. How then did we get to the current situation regarding RSI? In his article "NATO Standardization: an Organizational Analysis", James R. Carlton identifies four distinct periods o NATO efforts: A. the Institutional Phase (1949-57), B. a Consortium or Extramural Period (1957-68), C. the European Initiative Phase (1969-74), and D. the Two-Way Street Period (1974-80). Insofar as this format provides a vehicle to understand the way things came to be as they are today, I will also utilize the format.

A. Institutional Phase - due to the overwhelming presence of the U.S. weapons systems, thanks in part to the American Military Assistance Program, de facto standardization existed during this period. The rehabilitation of a Europe devastated by WW II eventually included a resurrection of the arms industries. Standardization represented a solidarity of will on the part of NATO to resist communist aggression. It was also good for U.S. arms producers who would otherwise have had to scale down production due to the demobilization.

B. Consortium or Extramural Approach - In large response to the perceived threat associated with the successful Soviet Sputnick launch, Europe was persuaded to assume its "fair share" of defense requirements. NATO was successful in standardizing five major U.S. systems during this phase; the M-44 torpedo, the F-104 Fighter, the Hawk, Sidewinder and Bullpup missiles. Standardization meant the purchase of American weapon systems by NATO European allies.

C. European Initiative Phase- the U.S. was suffering through the pangs of disillusionment with foreign commitments engendered by the disaster in Vietnam during this phase. An increase in Soviet threat perception coupled with a fear of U.S. disengagement, i.e. the Mansfield Amendment, forced a reassessment of NATO by the allies. The creation of the Eurogroup in 1968 was to stimulate increased European cooperation in the acquisition of weapon systems. This organization represented an attempt to provide a forum for European views on political and strategic issues.

D. The Two-Way Street Period- With the conclusion of the Vietnam episode, America once more looked to Europe and the Alliance. The legacy of Vietnam was twofold in relation to NATO. First, and perhaps foremost, the moral attitude of righteous anti-communism had been tarnished by our involvement in Southeast Asia. America was labeled imperialistic aggressors by many in those nations for whom it had fought two wars to preserve. Second, the cost to readiness of robbing Peter (NATO) to pay Paul (Vietnam) was significant. Combat readiness of NATO forces had declined drastically. In order to upgrade our capabilities, standardization was stressed both by the President and the Congress. The United States began an initiative to make standardization in research and development -- as well as procurement and support-- an integral part of the NATO planning process. Public Law 93-365 instructed the U.S. Secretary of Defense to "undertake a specific assessment of the costs and possible loss of nonnuclear combat effectiveness of the military forces of the North Atlantic Treaty Organization members, including the United States, to standardize weapon systems, ammunition, fuel and other military impedimentation for land, air and naval forces. The Secretary shall also develop a list of standardization actions that could improve the overall NATO nonnuclear defense capabilities or save resources for the alliance as a whole."[3]

Since 1980 it would seem that there are two distinct periods of defense related issues that may be associated with NATO force structure as well as the U.S. structure in general. During the initial Reagan defense buildup, (1980-1984) the U.S. defense industry experienced a period of unparalleled peacetime growth. This period resulted in a significant growth in the R&D of next generation weapon systems as well as the production and deployment of current state of the art systems. Since the U.S. defense community was thus on the cutting edge in the development of new weapons, it was only logical that systems procured and deployed by NATO would continue to be predominantly American. During the latter stages of the Reagan Administration and initial ones of the Bush Administration, there has been a downward trend in expenditures for Defense and thus a downturn in the development and deployment of new weapon systems as well. This has created a window of opportunity for the resurgent European defense community, which has experienced an upturn in keeping with the general economic community. As the European community moves from the planning board to actuality, there will be a commensurate lobbying for a greater share in the two-way street.

As the size of the weapons pie begins to shrink, in light of the move toward force reduction. And as the burden sharing issue increases, and with it a call toward a reduction in U.S. involvement, or at least investment. There will inevitably come a time in which the issue of RSI will generate into a matter of leverage. With the Europeans assumption of a greater share of defense expenditures, either through a U.S. pullback or a European increase, there will be a call for more standardization of systems by the procurement of European-built weapons. In fact it has been asserted that "many see our Alliance burden-sharing problems as another undesirable aspect of European efforts to build a Europe without Frontiers by the end of 1992. Two decades ago this would have been seen as the culmination of a long and successful road that began with the Marshall Plan in 1947. Today, many in the Congress and government see it either as a mechanism for subsidizing European technological and industrial competition with the United States, or for shutting U.S. commercial and military products out of Europe."[4]

The potential for serious conflict within the Atlantic Alliance has become much greater with the decline of U.S. dominance, with the perception of a less threatening Soviet Union, and with an emerging economic superpower (European Community). These issues could contribute toward the fragmentization of the consensus toward RSI within the members of NATO. While a good deal of thoughtful analysis has been generated toward the possible consequences of a successful nuclear and conventional force reduction program, little has been articulated with regard to the force structure, and the force replenishment policies that must come from these reductions. The economic competition between the U.S. and its European allies will make rational, reasonable decisions regarding the RSI aspects of future force deployment potentially a diplomatic minefield.

If the past can be seen as prologue, then the troubles associated with RSI will be more likely to increase in the near term. Now is the time to accommodate some of the more contentious issues that may eventually divide the members of the Alliance. One option that appears to offer U.S. firms the opportunity to participate in future business, both commercial and military, is the concept of teaming arrangements between U.S. and European companies.

> "Most of American industry, for its part, has begun to take notice of the opportunities, as well as the challenges, that 1992 affords. Defense should not lag behind other sectors of American industry. Those defense manufacturers with Europe-wide subsidiaries and distribution systems will, of course, benefit most from the lowering of barriers. Small and medium- size firms should, for their part, make every effort to learn more about 1992, and to explore creative teaming arrangements and joint ventures with European businesses that would enable them to exploit the free movement in Europe that 1992 will offer."[5]

Even with joint ventures, teaming of contractors and U.S. control of some European defense companies, there will inevitably be some instances where the issue of standardization of NATO forces becomes the focus of contentious disagreement between the European Community and the U.S.

There can be little doubt that the post-1992 environment for NATO procurement will require an adjustment on the part of U.S. policy makers in determining the appropriate relationship of the respective members.

CONCLUSION

There is a fundamental agreement on the part of the NATO Allies that significant changes to the force structure is in the offing. The elimination of the intermediate range nuclear forces has created a situation in which conventional capabilities have assumed a much greater importance. The escalatory ladder and the U.S. nuclear umbrella are no longer the security blanket that they once were. Calls for cuts in short-range nuclear weapons are almost certain to increase. As conventional forces continue to be reduced, then the importance of RSI will indeed be magnified.

What is required today is a plan for the implementation of RSI to accommodate the anticipated force reductions. The competitive Strategies Initiative focuses upon modernization programs which offer high battlefield leverage without the cost of attempting to match the Warsaw Pact "gun barrel for gun barrel".[6] This plan, effectively a "Grand Design" must address the political, miliary and economic issues associated with the implementation of an increased RSI program in a shrinking NATO budget.

The problems associated with the transfer of technology is another issue that must be addressed. Competition in the international market for weapon systems is extremely keen. Without proper control (through licensing of data rights etc.) companies can not be reasonably expected to participate in an broad based RSI implementation.

The goal of an effective RSI Program is to ensure enhancement of effectiveness with a commensurate savings in cost. "Most immediately, interoperability confers flexibility and perhaps staying power. With greater standardization, the argument runs, a simplification of logistics should be feasible, making it possible to put more resources into front-line forces. This sort of reasoning merges imperceptibly into the more general assertion that all savings arising from collaborative acquisition may be used to put additional resources into the cutting edge of the alliance's order of battle."[7] These words were included in my article for the Proceedings of the 1983 Federal Acquisition Research Symposium and are even more applicable today. While the threat, or rather the perception of the threat has changed over the last several years, the need for a more coherent strategy for the implementation of an effective RSI program has not changed perceptibly. It will be a challenge to both U.S. and European policymakers to ensure that the Alliance is strengthened by changes to the NATO force structure and increased, genuine cooperation with the Warsaw Pact and Soviet Nations so that the next forty years of NATO can be as effective as the last.

Concerning the impact of the "New Europe" on the U.S. Defense Industry, actions have already been initiated to establish agreed procedures for adoption and use of common standards for the "New Europe" market and the U.S. Canada markets. Negotiating an agreed standard with one centralized body in Europe instead of 16 national bodies, will reduce the cost of standardization ane production of competitive material items. If appropriately applied, this approach will make it easier for U.S. industry to access the European market for defense material provided the U.S. industry will diligently pursue improvements to become more competitive.

1..Politics Among Nations, Hans J. Morgenthau, p. 508.

2.. Dr. Robert B. Costello, Acquisition Office Shuffle will increase NATO cooperation, Armed Forces Journal, December 1988 pg. 70.

3.. Appropriation and Authorization Act of 1975, P.L. 93-365.

4.. Thomas A. Callaghan Jr., NATO at Forty, Journal of Defense & Diplomacy, Apr 1989, pg 23.

5.. Dov S. Zakheim, Armed Forces Journal, Dec 1988, Frontier-Free Europe: Will the US Be Ready?, pg. 66.

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THE MODULAR STAND-OFF WEAPON
FEDERAL ACQUISITION REGULATION WAIVERS AND DEVIATIONS
IN AN
INTERNATIONAL ACQUISITION

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ABSTRACT

The Modular Stand-Off Weapon program was a seven nation collaborative development and production program. Management of the program was in a three tier international management structure with the lowest tier, the International Program Office, being located in the host nation, the United States, at Eglin AFB FL. While the management was international, the Memorandum Of Understanding specified that the host nation's procurement practices as modified by the MOU would be used. The US system is more detailed and restrictive than any of the systems of the six other participants. This paper examines in particular the process of formulating and obtaining waivers and deviations to the Federal Acquisition Regulations, the problems encountered, and recommends several potential changes that would help any future efforts of this kind.

Background. The Modular Stand-Off Weapon (MSOW) program was an international cooperative development program. The proposed program was to be the project definition phase (NATO equivalent to US Dem-Val phase) based on the feasibility studies of the Long Range Standoff Missile (LRSOM), the Low Cost Powered Dispenser (LOCPOD) and a NATO Staff Requirement for MSOW. Discussions and negotiations on a Memorandum of Understanding (MOU) began in January 1986. The seven participants were Canada, Federal Republic of Germany, France, Italy, Spain, United Kingdom, and United States. The General MOU was completed and signed by all seven partictipating governments in July 1987. A request for proposal was released in September 1987. About mid way through the source selection process (May-June 1988) two of the participants, Canada and France, withdrew and the program was restuctured. After completion of the source selection evaluation two other participants, the United

Kingdom and the United States withdrew (September 1989) and the program collapsed. MSOW was unique in that it began the collaboration on a major system much earlier in the development process than did the more familiar F-16 and AWACS programs and also that it had to build its management structure from scratch rather than having an infrastructure (F-16 SPO/AWACS SPO) already in place to aid the collaborative efforts once they became a part of the program. Given the fate of the program hopefully there is something positive that can be gained from the investment of time and people.

Scope. In this paper we examine the process and difficulties of the process of defining, seeking and getting approved waivers and deviations to the Federal Acquisition Regulations (FAR), Department of Defense, Air Force and Air Force Systems Command Supplements to the FARs.

MOU Provisions. First it must be understood that while the program was under an international management structure of Steering Committee, Management Group, International Program Office, the latter being an internatioanl tennant on Eglin AFB, the contracting was done using US procedures as modified by the MOU. Specifically the MOU[1] states "The Host Nation will award and administer Programme Contracts on behalf of the Participants. This will be done in accordance with the Host Nation's laws, its procurement procedures and practices, and the provisions of this MOU and its supplements; provided that it is not contrary to its national law, each participant will waive national regulations, procurement procedures and practices, whenever possible, when it is necessary to meet the requirements of the pertinent provisions of this MOU and its supplements". Another section of the MOU identifies the US as the Host Nation. All the participants except the United States took a very broad view of what was required in the way of waivers and deviations to meet the requirements of the MOU. While not necessarily in agreement with the others the US accepted this broad interpretation in order to move the program forward.

The Process. Initially the US formulated a strawman RFP for the program based on the program requirements. Since US procedures were being used, this initial version was written in accordance with US requirements which included all the necessary clauses to comply with US laws. All clauses that the regulations indicated applied to US industry only were annotated as such in the RFP. During an early review of the RFP by all the participating nations (May 87) the other participating nations took exception to many clauses (see table)[2]. As shown by the table there were many clauses the other participants wanted action taken on before the RFP was released. The US preferred to wait until proposals were recieved from industry so that any requests for waivers or deviations could be combined with those identified by the particiapnts and the combined list then acted upon. After some negotiation, agreement was reached that only the deviation to DOD FAR 52.227-7013, Rights in Technical Data and Computer Software, would be requested prior to RFP release. The deviation was approved by the Defense Acquisition Regulation (DAR) Council in August 1987 and included in the RFP. After proposals were recieved, the participants agreed upon a final list of clauses that would require deviations or waivers. These are shown in the table. In March 1988 a special meeting of the MSOW Source Selection Advisory Council (SSAC) was held to consider this final list of requested waivers and deviations. Subsequent to that meeting, processing the requests began. In February 1989 the waiver of FAR 52.230-3, Cost Accounting Standards, had not been approved, but the participants were able to work around this by using a special contract provision referring to existing bilateral agreements and further agreeing to establish a set of procedures where none existed. This proved to be fortuitous because the waiver request was later denied. One of the most hotly discussed areas was that of patent rights. By June 1989 the DAR Council had disapproved the waiver request on Patent Rights (FAR 52.227-12). However the council did agree to reexamine this if a problem arose during contract performance. Since the contract was never awarded we do not know how this would have worked out. However, a deviation to the clause was approved. Examination of Records by the Comptroller General (FAR 52.215-1) was another thorny issue. No waiver had ever beeen granted on this FAR. As a result the Air Force Service Acquisition Executive did not sign out the request and disapproved it at his level.

Conclusions. Comparing the original list to the final list in the table shows the final list does not include many of the original requests. This is probably due to the fact that the industry proposals did not include any requests for these which caused the participants to withdraw them from the list. Also the final list contains many not on the original list. Both of these differences validate the original negotiation point to wait until the proposals were received to finalize the list of requested deviations and waivers. The waivers and deviations that were not approved may have caused problems for the non-US participants in obtaining approval for the contract award if the program had continued. In addition some of the participants were particularly unhappy that the disapproval of the waiver on records examination had not gone to the highest possible authority for consideration.

Recommendations. If we are serious about international collaboration, then some adjustments must be made to make it easier to get appropriate waivers and deviations to the FARs. One possibiltiy is to use the list generated by the MSOW experience as a baseline and make all those where deviations or waivers were approved for MSOW an automatic approval for any collaborative effort (i.e.

where the non-US participants are paying a share of the cost of the effort) Another possibility would be to incorporate into the FAR more latitude for specifying these type clauses as applying to US industry only or to performance in the US. As a minimum the table and this paper should at least be retained somewhere as a precedence guide for use with future collaborative efforts.

TABLE

WAIVERS AND DEVIATIONS FOR MSOW

* = action requested before RFP release
W/D= request withdrawn
A-D= deviation approved
D-D= deviation disapproved
A-W= waiver approved
D-W= waiver disapproved

TITLE		ORIGINAL MAY 87	FINAL MAR 88	FINAL ACTION
FAR				
52.203-1	Officials not to Benefit	X		W/D
52.203-3	Gratuities	X		W/D
52.203-5	Covenant Against Contingent Fees	X		W/D
52.203.7	Anti-Kickback Procedures	X	X	A-D
52.204-2	Security Requirements		X	A-D
52.212-8	Defense Priority and Allocation Requirements		X	A-D
52.215-1	Examination of Records by Comptroller General	X	X	D-D
52.215-2	Audit-Negotiation	X	X	A-D
52.215-22	Price Reduction for Defective Cost or Pricing	X	X	A-D
52.215-24	Subcontractor Cost or Pricing Data		X	A-D
52.215-30	Facilities Capital Cost of Money	X		W/D
52.215-31	Waiver of Facilities Cost of Money	X		W/D
52.227-3	Patent Indemnity		X	A-D
52.227-12	Patent Rights-Retention by the Contractor(Long Form)	*	X	D-W & A-D
52.230-3	Cost Accounting Standards	X	X	D-D

52.230-4	Administration of Cost Accounting Standards	X	X	D-D
52.245-2	Government Property (Fixed Price Contracts)	X		W/D

<u>DOD FAR SUPPLEMENT</u>

52.204-7005	Overseas Distribution of Defense Subcontracts		X	A-W
52.208-7000	Required Sources for Minature and Instrument Ball Bearings		X	A-D
52.208-7001	Required Sources for Precision Components for Mechanical Time Devices		X	A-D
52.208-7002	Required Sources for High Purity Silicon		X	A-D
52.219-7000	Small Business and Small Disadvantaged Business Subcontracting Plan (Master Plan)	X		W/D
52.223-7001	Safety Precautions for Ammunition and Explosives		X	A-D
52.225-7000	Buy American-Balance of Payments Program Certificate	*		W/D
52.225-7006	Buy American Act, Trade Agreements Act and the Balance of Payments	*		W/D
52.227-7013	Rights in Technical Data and Computer Software	*	X	A-D
52.227-7016	Contract Schedule Items Requiring Experimental, Developmental, or Research Work	*		W/D
52.227-7018	Restrictive Markings on Technical Data	*	X	A-D
52.227-7019	Identification of Restricted Rights Computer Software	*		W/D

52.227-7029 Identification of Technical Data	*		W/D
52.227-7030 Technical Data-Withholding of Payments	*		W/D
52.227-7031 Data Requirements	*		W/D
52.227-7034 Patents-Subcontracts	*		W/D
52.227-7036 Certification of Technical Data Conformity	*		W/D
52.227-7037 Validation of Restricitve Markings on Technical Data	*		W/D
52.231-7000 Supplemental Cost Principles	X	X	A-D
52.235-7002 Recovery of Nonrecurring Costs on Commercial Sales	*	X	A-W
52.242-7003 Certification of Indirect Costs		X	A-D
52.243-7001 Pricing of Adjustments	X	X	A-D
52.246-7001 Warranty of Data	*		W/D
<u>AF FAR SUPPLEMENT</u>			
52.209-9000 Certification of Department/Suspension Status	X		W/D
<u>AFSC FAR SUPPLEMENT</u>			
52.219-9000 Size Standard and Classification	X		W/D
52.222-9000 Equal Opportunity Preaward Clearance of Subcontracts	X		W/D
52.223-9100 Physical Security of Sensitive Conventional Arms, Ammunition and Explosives at Contractor Facilities		X	A-W

52.227-9001 Listing of Technical Data or Computer Software to be Delivered to the Government with Less than Unlimited Rights	*		W/D
52.227-9002 Contractor Standards for Contract Restrictive Markings	*	X	A-D

Note: Exact wording of the deviations can be obtained by contacting Ms Preta at AFDTC/PKR, Eglin AFB FL 32542-5000, DSN 872-3377.

ENDNOTES

1. General Memorandum Of Understanding Concerning General Arrangements for the Collaborative Development and Production of a Modular Stand-Off Weapon System, July 1987.

2. Modular Stand-Off Weapon International Program Office Letter, 24 Jan 1990, Lessons Learned, with attachments.

MANPOWER, PERSONNEL, and TRAINING

ACQUISITION WORK FORCE

ARTS AND HUMANITIES IN LEADERSHIP: IMAG'NATION AND INNOVATION

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ABSTRACT

The best way to present the nature of this research is to capture in the mind's eye a moment in the astonishing events that are drastically altering the economic, political, and social contours of Europe. That moment is the sudden collapse of the communist government in Czechoslovakia and the accedence to the Presidency of that country of a man who until recently had spent time incarcerated as a political prisoner - - the playwright Vaclav Havel. Like the musician and composer Paderevsky before him, the Arts had provided the unlikely breeding ground for the extraordinary and compelling qualities of leadership which have propelled Havel to the forefront of his country's surge towards freedom and democracy. There are many other contemporary and historical similar examples.

What is the relationship between the arts and humanities and leadership? Is the creative impulse of the artist related to "charisma" that is ill defined but often attributed to leaders? And if so, how? Can leaders in such divergent sectors as business, government, the military, the arts and the humanities learn to enhance their own skills by experiencing leadership challenges as other groups might deal with them?

It is hypothesis of this research that a mutually reinforcing relationship exists between the arts/humanities and leadership, which, once adequately explored and researched could lead to significant advancement in the education and development of leaders in all sectors of the society. This paper describes the research accomplished so far which is in its infancy and far from complete but which tends to support the hypothesis. It covers the research by the Defense Systems Management College (DSMC), the initial efforts at introducing arts and humanities into the DSMC curriculum, and suggested further research.

INTRODUCTION

The emblem of the Defense Systems Management College (DSMC) contains the motto "Ductus * Doctrina * Dominato." Translated, the motto reads, "Leadership * Scholarship * Management." The role of the college in promoting scholarship and management is readily understood and the college has enjoyed considerable success in system acquisition education. However, the term leadership is ill-defined at best.

A great deal is yet to be learned about the make-up of leadership and the techniques of educating leaders. Most students attending DSMC, particularly the military students, think they know what leadership is and how to do it. The college provides a curriculum to address leadership elements and encourage further study.

This research is part of the ongoing search for truth in the definition of leadership and in search of techniques for educating leaders. Described are the foundation of the research, some exploratory results and proposed follow-on effort.

FOUNDATION OF THE RESEARCH

There is a great deal of emphasis on improving national competitiveness. Prime in such an effort must be development of effective leaders. What makes a leader? Can we determine the attributes and provide an educational experience that will accelerate development?

This research was founded in the design of experiential courses for DSMC students. A current initiative addressing quality brought us to techniques for defining quality. Pirsig finally concluded in **Zen and the Art of Motorcycle Maintenance** that quality is not definable.[1] If that were true, how could we provide an educational experience that would define quality so we could manage it?

In a curriculum development session in search of ways to portray concepts like quality, vision and creativity[2] a process evolved from our experiential learning techniques.[3] It seemed to present our first real opportunity to come to grips with educating in the undefinable area. Specifically, it provides the students with experiences along a continuum which increasingly deviates from the definable and knowable until the students fly off on their own beyond the defined mark.

This concept was in the author's mind while attending an Aspen Institute weekend on "The American Experience."[4] The seminar covered the influential documents supporting the foundation of our country and the people responsible for the vision and quality of their composition. Time and again the seminar participants longed for indications that we are developing leadership that can deal effectively with the evolving environment. As the seminar leader let the group explore the need, the problem of related education appeared as a real stopper.

Gardner says we can define the tasks of leadership but stops short of selecting and educating for "leadership."[5] Werner Earhard talks of a "presence" in leadership[6] which is conceptual but not participatory. With these thoughts swirling in mind the author attended a dinner social gathering of the Aspen American Experience seminar which included musical entertainment as well as poetry by the seminar leader.

During this experience came the "great AHA." **The Arts and the Humanities provide a road to educating for improved leadership education.** One could feel the potential for bringing students to the edge of an undefinable concept (such as quality, vision or creativity) through poetry, dance, music, painting or theatre and seeing them project beyond the same or some other medium. The thought is consistent with one promising focus of recent research about the use of analogies in problem solving: those who understand one topic can apply this knowledge elsewhere through analogy.[7]

EXPLORATORY RESEARCH: THE IMPACT OF THE ARTS AND THE HUMANITIES ON LEADERSHIP

Peter Neary while Director of the Aspen Institute Executive Program called my attention to two documents bearing on the subject. The first, "The Liberal Arts Major in Bell System Management"[8], states, "The humanities and social science majors in particular continue to make strong showing in managerial skills and have experienced considerable business success. We hope and expect that to continue."

The second, "Can humanities Improve Effectiveness?"[9], concludes, "These findings suggest the study of humanities may result in more enlightened managers with stronger leadership skills, improved interpersonal relations, enhanced decision making skills, and increased confidence to deal with the complexities of their job assignment and their own being." Consistent with the latter part of that conclusion, Jacques d'Amboise in "Why I Teach"[10] states, "When a youngster learns how to dance, he learns he can control his life."

Frank Maurane wrote in the Boston Globe about the people behind the Tufts Health Plan in Boston who think being creative keeps people healthy.[11] They sponsored a program, On My Own Time, to encourage workers of local companies to create and exhibit works of art in their spare time. The show's various participating companies were quickly deluged with an outpouring of paintings, sculptures, ceramics, even quilts from employees who are not full time artists. The show is yet another example of how corporations are exhibiting greater appreciation of what visual arts can do for the work place.

Teresa Amabile discussing her book, **Growing Up Creative**[12], said, "creativity rests on three things: talent or training in a given area such as music, science or art; a disciplined work style and an innovative way of thinking that allow for new ideas and possibilities; and intrinsic motivation, Amabiles's term for the simple joy that comes from doing something for it's own sake, as a labor or love." . . . "Amabile said she has found in her research that most creative work is not done by people who were called geniuses as children. Creativity is not the same thing as giftedness or intelligence. Talent alone is no indication of what an individual will accomplish."[13]

There is an ever growing list of circumstantial evidence supporting what many have tried to articulate as a need for greater investment in the arts and the humanities as we are driven harder and harder by technology. The trail is leading to some specific relationships that can spur the competitiveness of the nation.

EXPLORATORY RESEARCH: THE RELATIONSHIP OF THE ARTS AND THE HUMANITIES TO LEADERSHIP

Earlier literature exploration[14] identified arts and humanities linkage in the background of well-known leaders. There is a possibility that all of us have certain gifts in the arts and/or the humanities that indicate the potential for leadership. Another possibility is that education in the arts and/or the humanities influences leadership development. Of course, combinations of these two would be powerful. Identified gifts or education successes may provide hints in how to maximize the potential for education. I undertook four efforts to better define the possible linkage. One was a further literature search and analysis of past and present public figures well known as leaders. The second was analysis of the impact of two socratic seminars conducted by Peter Neary at the Defense Systems Management College. Third was an exploratory analysis of DSMC Myers-Briggs Type Indicator data for the second Program Management Class in 1987. Fourth was an interview process with leaders in private industry. Details of the four efforts follow.

ARTS AND THE HUMANITIES: SOME PAST AND PRESENT PUBLIC FIGURES

Table I raises the question of causal relation. Is there some innate artistic ability that enhanced leadership development? Were the artistic and leadership developments separate? Did education in the art or the humanity enhance leadership?

Table I lists some well known figures, their leadership focus and a relationship to arts and/or humanities along with a reference for the association. Obviously, the point of

TABLE I
LEADERS AND ARTS/HUMANITIES RELATION

SUBJECT	LEADERSHIP APPLICATION	ARTS/HUMANITIES FOCUS	REFERENCE
Harry S. Truman	President, USA	Music	Margaret Truman, Harry S. Truman William Morrow and Co., New York, 1972
Charles M. Schulz	Army Squad Leader	Cartoonist (Peanuts)	Rheta Grimsley Johnson, Good Grief: The Story of Charles M. Schulz, Pharos Books, New York 1989
Franklin D. Roosevelt	President, USA	Actor/Editor	Geoffrey C. Ward, A First Class Temperament, Harper and Row, New York, 1989 Geoffrey C. Ward, Before the Trumpet, Harper and Row, New York, 1985
George Caleb Bingham	Politician	Painter	Verlyn Klinkenborg, His Art Brought us Face-to-Face With Our Land and Ourselves, Smithsonian, March 1990
Paul Brown	Football Coach	Actor	Citizen award dinner, Massillon, Ohio
Hyman Rickover	Admiral US Navy	Music	Norman Polmar and Thomas B. Allen, Rickover, Controversy and Genius, Simon and Shuster, New York 1982
Lee Iaccoca	CEO Chrysler	Author, Debate	Lee Iaccoca with William Novak, Iaccoca: An Autobiography, Bantam Books, New York 1984
Pope John Paul II	Religious Leader	Poet, Philsopher, Actor	George Huntson Williams, The Mind of John Paul II, The Seaburg Press, New York 1981
Ulysses S. Grant	President, USA Army General	Student of Literature	William S. McFeely, Grant: A Biography, W.W. Morton and Co., New York 1981
Dwight D. Eisenhower	President, USA	Student of Military History	Stephen E. Ambrose, Eisenhower: Soldier, General of the Army, President elect, Simon and Shuster, New York 1983
Douglas MacArthur	General of the Army	Student of History	Frank Kelly, MacArthur: Man of Action, Doubleday, Garden City, New Jersey, 1950
Winston Churchill	Prime Minister of Great Britain	Painter, Author	NOTE (1)
Ronald Reagan	President, USA	Actor	NOTE (1)
Vaclav Havel	President, Czechoslovakia	Writer	NOTE (1)

NOTE (1) No specific reference is cited for these leaders. The linkage is well recognized.

the Table is to show that arts and/or humanities played a part in their development. Beyond that the Table shows a diversity of background in the individuals though several held the same or similar leadership positions. The group is international and represents a variety of careers but holds a common bond of some substantial renown for participation in the arts and/or the humanities.

Harry Truman has been recognized as one of our most effective Presidents. Though he was far from professional at the piano, he kept up his interest and prowess at a level that allowed him to play for selected audiences at the White House. It is of interest to note daughter Margaret's professional success as a mystery writer. In her father's biography she wrote, "Dad's thirst for good music sometimes drew him out of the White House in the evening. In the summer he often drove down to the Watergate to listen to the outdoor concerts there. He would arrive late and sit in his car on a road above the amphitheater, and then send me the concert program with comments on the performances."

Charles Schulz, author of Peanuts, may not be considered an artist by the community but his work certainly contains much of the creative elements associated with our concepts of art and communication. It is little known that Shultz served in the Army and threw himself into the responsibility to achieve recognition as a squad leader in a very short time.

Franklin D. Roosevelt led the United States through World War II depending in large measure on his communication with the American people. Geoffrey C. Ward in Before the Trumpet provides some insight about young Franklin - some aptitude in art (Page 159), an essayist Page 163), organist (page 192), actor (page 204) and ultimately an editor for the Harvard Crimson. Reviewing FDR's more mature background in Geoffrey Ward's A First Class Temperament reveals Franklin as a better actor than playwright, a better editor than author. When confronted with a clean piece of paper he did not do well in communicating but given a start he was unparalleled in delivering the message.

George Caleb Bingham probably is the least known of Table I to the reader. But he may be the best example of a relationship between painting and leadership. His paintings, "Fur Traders Descending the Missouri" (1845), "Raftsmen Playing Cards" (1847), "The Country Election" (1852) and "The Jolly Boatmen" (1857) are just a few of his acclaimed works. "But the field of American art did not allow enough scope for the natural ambition of a man like Bingham." He ran for the Missouri legislature in 1846 and was narrowly defeated but was successful in 1848. He threw himself more and more into his political ambitions and though he continued to paint until death in 1879 there was little merit in his work after 1857.

Paul Brown is recognized in the Football Hall of Fame as a successful innovator and coach. He presented a problem in identifying a linkage with arts and humanities that the author was sure existed. Then at a citizen awards banquet in his hometown, Massillion, Ohio, he said "as I stood on the stage in my first play I recognized the necessity of preparing to carry my part in presenting the message to the audience."

Hyman Rickover is well known for his genius and controversy as the father of the nuclear submarine navy. After a slow start in school he graduated early in the February Class of 1918. An entry in his record shows that for "Music" he studied the music of his graduation. When interviewing for his organization he asked the candidate to name the last five books read.

Lee Ioccoca, CEO of Chrysler, well remembers the teacher who made him write essays and learn the art of communication. "At that point, Miss Raber started us on extemporaneous speaking. I was good at it and as a result joined the debate team. . . That's where I developed my public speaking skills and learned how to think on my feet. . . the experience of being on the debate team was crucial. You can have brilliant ideas, but
if you can't get them across, your brains won't get you anywhere."

Pope John Paul II is recognized as a dynamic leader in world religion. His biography contains much about his prowess in poetry, writing and philosophy. Possibly the most surprising of the linkages may be his background as an actor. . . "he is still proud of having taken so many leading roles on the stage in high school in his native Wadice and in the apartments of the underground theatre in occupied Cracow..."

Ulysses S. Grant had a difficult youth from an educational standpoint, not having good facilities or encouragement for the endeavor. But after entering the Military Academy there is some insight into his bent. "There is a fine library connected with the academy from which cadets can get books to read in their quarters. I devoted more time to these than to the course of studies... It is difficult to know how important this world of imaginative literature remained for Grant. In later life he disliked discussing literary matters, perhaps because of his lack of formal training or possibly because he liked the books better than the talk about them."

Dwight D. Eisenhower was born and raised in strict surrounding which did not encourage creativity or vision. But in his elementary studies he found an interest that whetted his appetite for learning. "The subject that really excited him, however, was one that he pursued on his own, military history. He became so engrossed in it, in fact, that he neglected his chores and his schoolwork. His concentrated persistence in following his curiosity, the time and energy he put into reading military history, alarmed his mother. . . She took his books away from him and locked them in a closet. But he found the key to the closet. . . I would sneak out the books."

Douglas MacArthur was dismissed by Harry Truman as Commander of Far East Forces over ideological differences. But he is considered as one of the great generals. Born in a military family he immersed himself in the writings of military history preparing himself for the great situational conflicts he was to face.

Winston Churchill was an effective leader during England's struggle in World War II. His ability as a painter is considered worthy of professional status. He often remarked about the relaxation and focus his work at the easel provided.

Ronald Reagan is called the "Great Communicator" a title well deserved from his performance as President. The linkage as communicator to his professional years as an actor is obvious but the linkage as a visionary in getting elected and projecting a philosophy may be missed.

Vaclav Havel is representative of a large number of national leaders rising in the new era of Eastern Europe. He is a professional playwright at the leading edge of modern thought almost forced by the Czechoslovakian people to accept their presidency. The ascendance of similar leaders in other countries has raised the speculation that "intellectuals" should accept more leadership responsibility all over the world.

One name not included in Table I is Adolph Hitler. This was done purposely so as not to raise the issue whether Hitler was a leader (requires a definition) and if we want to distinguish "good" leaders and "bad" leaders. Nevertheless Hitler's linkage to p inting is well known and we will have to sort out that implication during more research on the subject.

The Table includes well known figures who reached relatively high rank in professions holding considerable visibility. The only detail correlation in such a small sample may be the affinity for reading held by the three great Army generals, Grant, MacArthur and Eisenhower. But the author continues to find general arts and humanities linkages wherever the background of great leaders is searched. This is not to indicate that the focus of the research only should be at that level. We should be interested in leadership at all levels of society and its enterprises - local, state, national - cub scouts, PTA, city council....

ANALYSIS OF SOCRATIC SEMINARS

Peter Neary while Vice-Chancellor of the North Carolina School of the Arts conducted seminars at the Defense Systems Management College in December 1989 and January 1990. They were designed to provide insight into the impact socratic exploration of great documents of history might have on leadership. The participants were asked to write the answers to three questions before and after the seminar discussion:

* Leadership is?
* Personal values are?
* The relationship between personal values and leadership is?

Though the subjective evaluation was far from conclusive I believe through evaluation of the answers and discussion with the participants that the result was clear. The seminars broadened and deepened the participants' understanding of leadership and personal values and the relationship between those terms. Much more work is required in the design of such seminars and the analysis of results but the approach certainly has merit.

MYERS-BRIGGS TYPE INDICATORS RELATED TO ARTS/HUMANITIES INTERESTS

DSMC has accumulated a data base for Program Management Course students. We like to think that DSMC students are chosen as "fast trackers" in the defense system acquisition career field. In support of this paper there was only a brief time available to manipulate the volume of data available. The initial interest was based on a statement by Otto Kroeger at DSMC.[15] His startling observation was that 93% of the flag rank officers fall in one particular designation (the "TJ" corners of the Myers-Briggs matrix) whereas an even distribution would predict 25%. Would some relationships to the arts and the humanities established by this population explain the data?

The DSMC data has some information about the student interests and perceptions about themselves related to their Myers-Briggs type indicator. So I worked with Michael Krause in an attempt to show relationships between the arts, the humanities, and the Myers-Briggs type indicator for all military students in the second 1987 class. No correlation has been established segregating these ("TJ") students from others. In gross terms the data showed a rather homogenous interest and perception on the part of all students.

The interesting fact is that of the 195 *military students* selected for the class, 118 (about 60%) are the type dominant in flag ranks. We were able to separate the students by ranks and found that the same proportion held true at the rank just below flag rank (06, Navy Captain, Colonel). What was the discriminator that got them promoted? We have not yet performed an analysis to establish a causal relation. In addition, at least one of the 06 rank in the 1987 class has been promoted. What was that discriminator? An interview technique may help us sort out the answers.

The purpose of discussing this incomplete data is to show that it exists for some initial research on the linkage of the arts and the humanities to leadership ranks in the military.

INTERVIEWS WITH INDUSTRY

The upper management group for a major defense plant agreed to participate in a trial interview process to evaluate the contribution of the arts and the humanities to leadership. These responsible managers reported to the manager of a defense plant employing about 6000 personnel engaged in supplying high technical content systems. Titles included:

* Manager, Administrative Operations
* Manager, Information Processing Systems
* Assembly Operations Manager
* Engineering Manager
* Program Manager
* Missile Manager
* Manager of Human Resources

After a presentation to the group essentially covering the background of the research as described herein, I interviewed each separately. The interview was centered around the following inquiry:

> Do you have an inherited interest in the arts or humanities? If so describe.
>
> Did an educational experience in one or more of the arts or humanities play a part in your leadership development? If so describe.
>
> Describe your leadership style, e.g., inspirational, technical, collegial, professorial or words of your choosing.
>
> How important to your leadership development is your inherited interest in the arts or the humanities? (1. very important, 2. important, 3. somewhat important, 4. not important).
>
> How important to your leadership development is your educational experience in the arts or the humanities? (1. very important, 2. important, 3. somewhat important, 4. not important).

All found linkage to inheritance and all but one considered the educational experience a contributor. Most recognized the styles of leadership suggested by the single word and selected from those or easily chose other words: participative, instructional, inspirational (2), collegial (2), "the golden rule." Numerical analysis of the responses on importance of inheritance and education showed all in the somewhat important or higher. The numerical average for inheritance was 1.7; for education 1.4

(between 1 very important and 2 important).

The real benefit to me was the discussion surrounding the answers. In conversation with the human resource manager the term "credibility" became a central focus in leader selection. As I reflected on the other conversations and the research to date, the concept of active and passive components of credibility took shape. Active might be components like vision, creativity, and projection of self while passive might be components like ethics, morals and compassion. The arts would be linked to the active components and the humanities linked to the passive components.

The process should be refined but this initial effort seemed to demonstrate a great value for personal interview to further evaluate the linkage of the arts and the humanities to leadership.

SUMMARY AND RECOMMENDATIONS

So there seems to be something basal about the arts and humanities in leadership but what is causal? A recent Request for Proposal (RFP) by The National Endowment for the Arts on "Study of Relationship Between Instruction and Experience in the Arts and Performance on Standardized Tests," illuminated the type of problem we confront. A respected authority commented on the RFP[16], "Over the years the relationship between the study of music and the achievement of non-musical outcomes has attracted the interest of innumerable doctoral students seeking dissertation topics......She did a thorough study of the literature and in the end she realized, as has everyone else who has looked into the matter, that the current literature is inconclusive and that it is virtually impossible to design a study that will clearly establish causation."

The data base contained in industry and government regarding the background of their leaders is tremendous though probably incomplete in some specific critical areas. I suggest that a rigorous search of that data base can yield some useful correlations of arts and humanities with leadership potential. More important is the interest of industry and government in establishing causal relations so we can develop better leaders faster. I suggest that industry and government will be willing participants in studies to advance the definition of causal relations of the arts and the humanities in leadership.

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Air Force Research Program for Manpower, Personnel, and Training (MPT) in Systems Acquisition

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ABSTRACT

The Human Resources Directorate of the Armstrong Laboratory (ALHRD), formerly called the Air Force Human Resources Laboratory (AFHRL), is engaged in an extensive research program aimed at providing analytical tools and data base linkages to help decision makers and analysts ensure manpower, personnel, and training (MPT) issues are an integral early part of the acquisition of major weapon systems. Congress and the Department of Defense have established specific MPT requirements in law and directive. The services have implemented these in varying programs, regulations, and methods. The Air Force's IMPACTS (Integrated Manpower, Personnel, and Comprehensive Training and Safety) program is relying heavily on currently existing tools and data bases. But these are not integrated or appropriate for the specific MPT acquisition issues. Therefore, a long-term research program is underway to provide these integrated tools. There are eight projects underway to provide the decision support systems, optimization models, and data base linkages needed by System Program office (SPO) analysts and Major Air Command (MAJCOM) planning personnel: Specialty Structuring System (S3), MPT Functional Relationships, MPT Decision Support System (DSS), Weapon System Optimization Model (SYSMOD), Training Systems for Maintenance (TRANSFORM), Logistic Composite Model (LCOM), Occupational Research Data Bank (ORDB), and Weapon System-Specific Job Analysis (WSSJA). The Army and the Air Force have been cooperating for some time in the development of MPT tools. The Army's HARDMAN III set of tools has recently been developed. The Air Force is working with the Army to ensure compatibility between the respective MPT tools and to enhance each service's capability to meet the MPT requirements.

INTRODUCTION

The acquisition, or modification, of major weapon systems by the military services is a long-term, extremely complicated, and very costly process. In an era of decreasing defense budgets, each system is coming under increasing scrutiny as to need, requirements, logistics support, and manpower constraints by both Congress and the Department of Defense (DoD). When up to 85% of the total life cycle cost (LCC) of a weapon system is determined by Milestone II (as shown in Figure 1), the earlier manpower, personnel, and training (MPT) as well as design issues are established properly, the greater the cost savings. It has been estimated

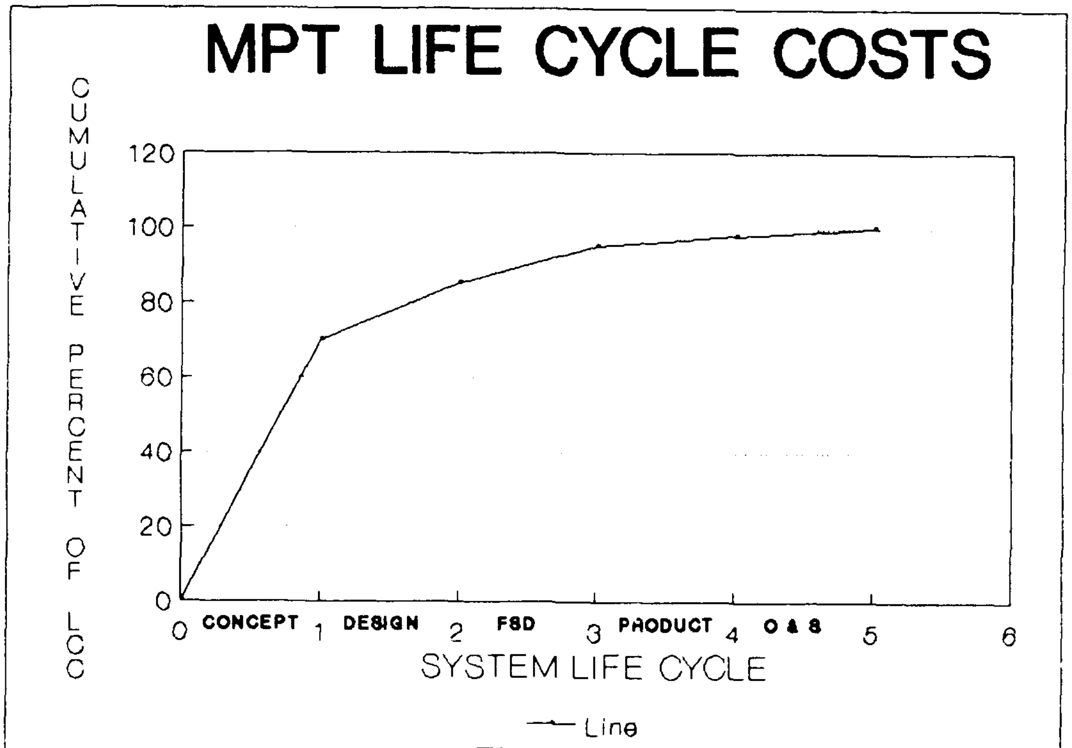

Figure 1

that between 45 and 62% of the LCCs of a weapon system can be attributed to MPT related issues. The LCCs involve not just the system production and delivery, but also the support and maintenance needed over its entire life. To clarify terminology, manpower refers to the number of positions needed, personnel to the types of people required and their characteristics, and training to what they need to know to do the job.

The objective of the long-term, comprehensive MPT research program at the Human Resources Directorate of the Armstrong Laboratory (ALHRD), formerly called the Air Force Human Resources Laboratory (AFHRL), in Air Force Systems Command (AFSC) is to help System Program Offices (SPOs) and Major Air Commands (MAJCOMs) develop the most supportable weapon system at the least LCC, evaluate MPT requirements of design, and set MPT constraints for design. Analytical tools and data base linkages are needed to accomplish these objectives as well as quantify the impact and emphasis needed for consideration of MPT issues throughout the acquisition process. Operations research, systems analysis, statistical methods, and computer modeling techniques are being employed to develop these tools and make them available to decision makers and analysts. This paper will identify the requirements driving the MPT research program; describe the eight analytical models, tools, and data bases being developed; and discuss joint service cooperative MPT research efforts.

REQUIREMENTS

Congress, in the FY87 Defense Appropriations Act, required the Secretary of Defense to provide manpower and cost estimates at Milestones II and III for approval prior to entering the next phase of the acquisition process. These requirements were codified in Title 10, United States Code, Section 2434 [14]. The DoD formally implemented these requirements in DoD Directive 5000.53 in December 1988 [1]. This directive addresses the entire MPT area, including safety (health hazards) and human factors. It calls for specific manpower reporting requirements in the form of a Manpower Estimate Report (MER), development of a baseline comparable system (BCS), and supporting documentation. The DoDD 5000 series is currently undergoing extensive revision to provide a comprehensive and coordinated direction for the entire acquisition process.

The three services had implemented the program in differing detail before the DoD Directive came out. In the Army, the program is called MANPRINT (MANpower and PeRsonnel INTegration), in the Navy it is HARDMAN (HARDware and MANpower), and in the Air Force, it is now IMPACTS (Integrated Manpower, Personnel, And Comprehensive Training and Safety) [8]. The Air Force's original MPT program was called RAMPARTS (Readiness Achieved through Manpower, Personnel, And Requisite Training and Safety). The Army has developed a special MANPRINT regulation, AR 602-2, which requires the implementation of MANPRINT methods throughout the Army acquisition process. A recent book on the MANPRINT process provides an excellent description of the concept from a systems integration viewpoint [4]. The Navy is lagging behind the other services in formal implementation of the program.

Presently, the Air Force is developing its own MPT regulation, under the AFR 800 series. The regulation calls for establishment of IMPACTS Planning Teams at the MAJCOMs, development of MPTS-Descriptions for each major weapon system, and preparation of the needed documentation. The Air Force has a Memorandum of Agreement (MOA) signed at the two-star level between Air Staff offices and the MAJCOMs implementing the MPT program. It established an 06-level steering committee which meets twice a year to discuss MPT acquisition issues and guide the MPT program implementation. It includes representation for each signer to the MOA. Since 1986 the Air Force has had an MPT Directorate within the Aeronautical Systems Division (ASD/ALH) of AFSC working to instill awareness of MPT issues in all acquisition agencies in the Air Force [11]. The Air Staff Directorate of Productivity's Manpower Requirements and Organization Division (HQ USAF/PRQE) is the focal point for the IMPACTS program. They publish a bi-monthly bulletin and are developing training programs, similar to those of the Army, for Air Force-wide implementation. To energize research into operational concerns throughout the Air Force, AFSC has a process whereby Air Force organizations can request research under MPT Technology Needs (MPTNs). During FY89, most of the MPTNs generated dealt with the acquisition process and the lack of analytical tools and integrated data base information to address MPT issues [7].

RESEARCH PROGRAM

ALHRD and its parent organization, the Human Systems Division (HSD), have been working in this area for some time. ALHRD recognized this problem early in FY87 by establishing the MPT Technology Branch in its Manpower and Personnel Divsion (MO) at Brooks AFB, Texas. A special inter-disciplinary team of researchers including industrial/organizational psychologists, operations research analysts, and computer programmers was established in the branch. This was a change of direction for the division from its traditional research focus, but it was an attempt to meet Air Force needs. In May 1987, this new branch sponsored the first Air Force-wide MPT conference in San Antonio, Texas [9]. Under the concept "Themes for a United Direction," the conference provided a firsthand look at MPT issues from three prespectives: users, researchers, and planners. Also present were personnel from the Army and Navy. A MPT library was established within the branch to document the MPT related issues and avoid duplication of work.

The branch concentrates on the early and later phases of the acquisition process, but does not directly consider design influences. The two areas of MPT research within the branch deal with Decision Support Systems and Modeling/Database linkages. There are five projects being conducted in the first area: the Specialty Structuring System (S3), MPT Functional Relationships, the MPT Decision Support System (DSS), the Weapon System Optimization Model (SYSMOD), and the Training Systems for Maintenance (TRANSFORM). In the second area there are three projects: the Logistic Composite Model (LCOM), the Occupational Research Data Bank (ORDB), and the Weapon System-Specific Job Analysis (WSSJA). Each of these projects will be described to give some idea of the type of analytical work being conducted and the issues being addressed.

Specialty Structuring System. Within the Air Force the prime driver for developing any MPT solutions involves the Air Force Specialty (AFS), or occupation, an airman works in. The assignment process, manning consideration, and the training pipeline all use this one factor. RIVET Workforce is an Air Force initiative to restructure the AFS classifications to make economies across weapon systems. Unfortunately, this was not done in a systematic and logical manner. S3 is a analytical tool designed to group tasks into jobs and jobs into specialties in such a way that specialties are developed to support a given weapon system in the most efficient manner [13]. This involves developing an architecture and a methodology for considering MPT tradeoffs while allocating tasks to jobs and jobs to specialties across the entire weapon system acquisition process.

The model was developed in three phases. Phase I produced a model that outlined variables to be considered and MPT tradeoff processes in a spreadsheet format. Phase II used this model as a starting point and broadened the potential range of MPT tradeoffs, refined the processes by which the tradeoffs are considered, and produced a demonstration model for use in front-end analysis (FEA). In addition, specialty structuring issues that need to be addressed before a fully operational S3 can be developed for use during the Demonstration/Validation (DEMVAL) and Full-Scale Development (FSD) phases of the acquisition process were identified. Detailed design specifications for the model were developed for the Pre-concept and Concept Exploration phases while preliminary specifications were developed for the DEMVAL and FSD phases. Phase III, the final phase of model development, is currently underway and involves the development of detailed design specifications for the DEMVAL and FSD phases and a working S3 microcomputer prototype. Finally, a software implementation plan, training package, and users' guide will be produced.

MPT Functional Relationships. To permit tradeoffs between the various MPT factors involved in the acquisition process, quantifiable formulas are required. This stream of research, to begin later this year, will identify and develop analytical formulas for the MPT factors. Functional relationships address the interaction of individual MPT processes. Such relationships range from the micro (task or subsystem level of a weapon system) to the macro (fleet level). These relationships could range from simple calculations to extensive algorithmic logic, each specified at the appropriate level of detail. Some relationships being considered for evaluation include (1) length of training, training burden, and aptitude; (2) retention and aptitude; (3) productive capacity, experience, and aptitude; (4) training time and training technology; (5) manpower requirements, workload, and number of specialties; (6) work efficiency, workload, and aptitude; and (7) MPT pipeline parameters. As a relationship is quantified and the resulting equation developed, it will be incorporated into other MPT models and tools being developed.

MPT Decision Support System. The MPT DSS is a new major research effort just getting started. Primary analysis goals are to validate that emerging designs meet MPT constraints imposed on contractors and to provide personnel and training planners with information and decision processes to set up efficient training and personnel pipelines before weapon system delivery. Although it will support all phases of the

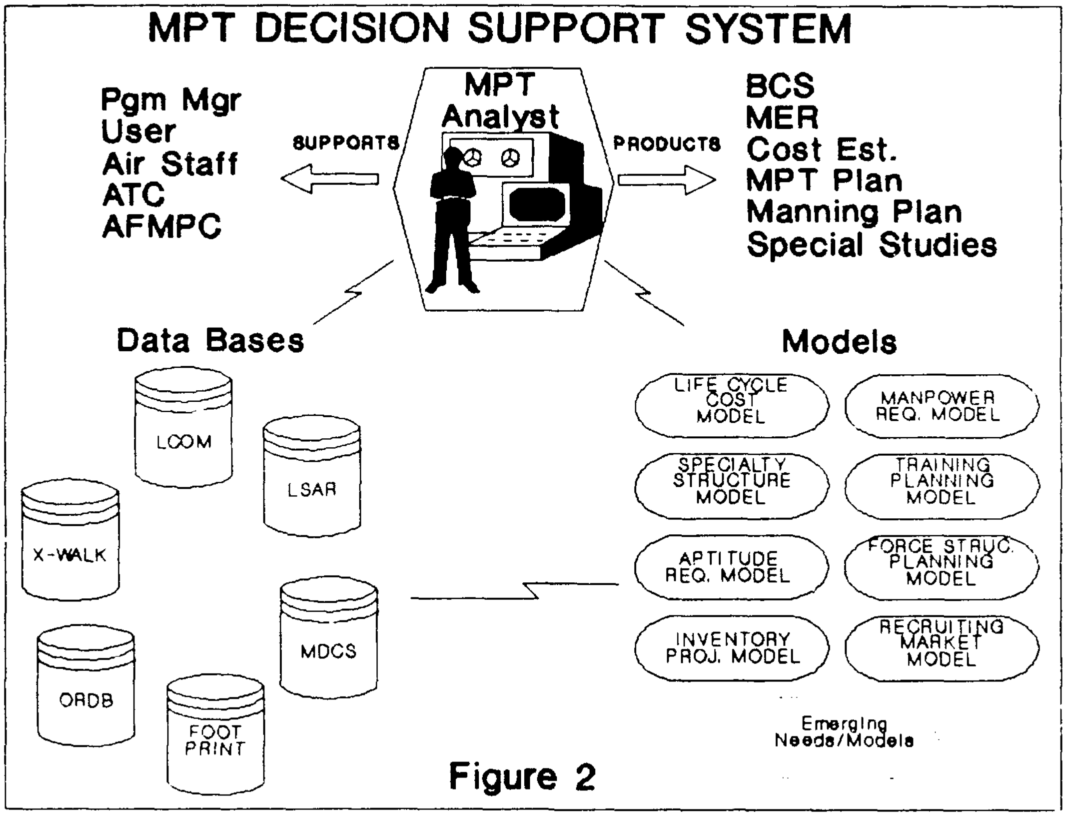

Figure 2

acquisition process, it will be used primarily by SPO analysts, decision makers, and design evaluators in the post-Milestone I activities. It will be based on the results of a recently completed study of MPTS factors in the system acquisition process for HSD, a FEA of an MPT modeling architecture currently underway, and an evaluation of the Army's HARDMAN III set of MPT tools. The MPT DSS is a micro-level analysis tool designed to extract data from several task-level data bases, develop a BCS architecture and library, and integrate existing or develop new analysis tools [2]. Figure 2 is a depiction of this process.

The BCS methodology is a key component of the MPT DSS and will be used in all phases of the acquisition process. It will incorporate task-level data, beginning with current weapon systems for predecessor information and replacing it with actual design data in later phases. The data base integration part of the MPT DSS will provide the needed task-level data from such sources as the Maintenance Data Collection System (MDCS), the Core Automated Maintenance System (CAMS), LCOM, ORDB, and the Logistic Support Analysis Record (LSAR). If some detailed data is not available, then Subject Matter Experts (SMEs) will be needed to supply the missing data. The analysis tool technology is core to the MPT DSS. There are seven

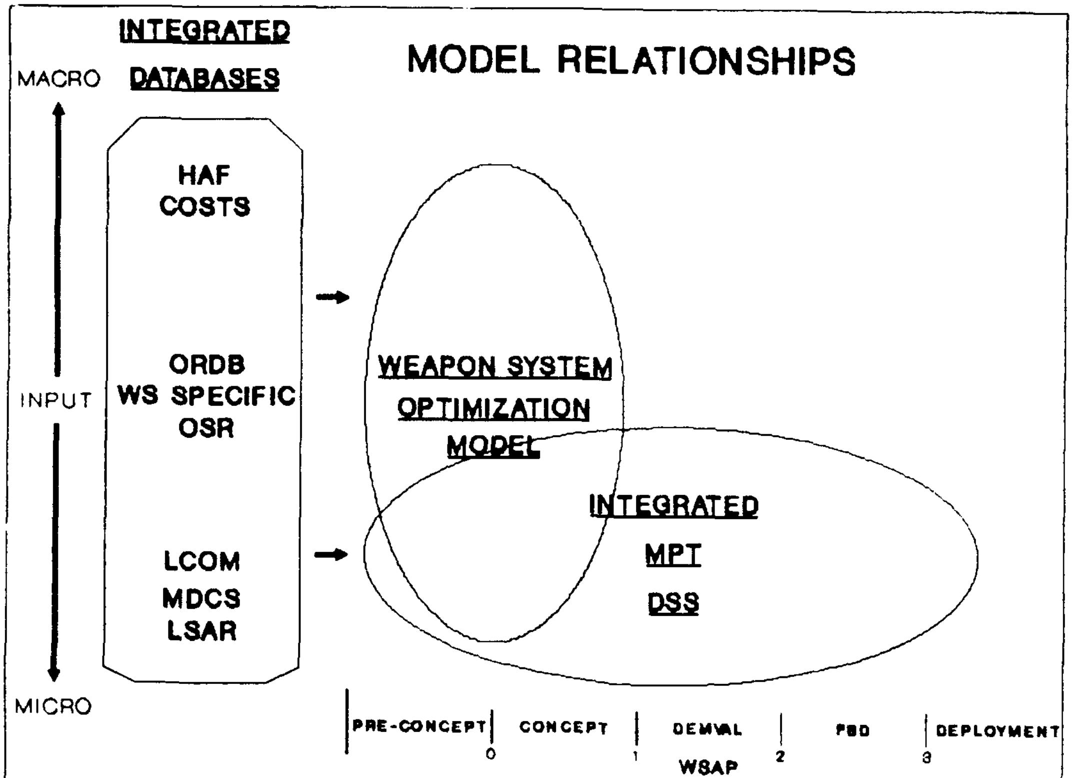

Figure 3

analysis methodologies that will be incorporated or developed along with four tradeoff techniques. The methodologies include (1) specialty structuring, (2) manpower estimation, (3) personnel aptitude and characteristics, (4) training resources and requirements, (5) LCC models, (6) force structuring, and (7) inventory projection. The tradeoff techniques include (1) functional relationships, (2) measures of effectiveness (MOEs), (3) MPT pipeline considerations, and (4) specific integration capabilities.

Throughout its development the MPT DSS will be demonstrated on a chosen weapon system. After the development, an extensive test and evaluation program will be conducted, followed by refinement and enhancements. Full documentation will be developed for the complete software system including users' manuals, maintenance document design specifications. The microcomputer MPT DSS will provide an integrated data linkage and analysis tool for SPO decision makers and analysts.

Weapon System Optimization Model. SYSMOD is designed to be a new constraint developing tool for use in the pre-Milestone I phases of the acquisition process. It will provide MAJCOM planning personnel and MPT Planning Team members with a model to

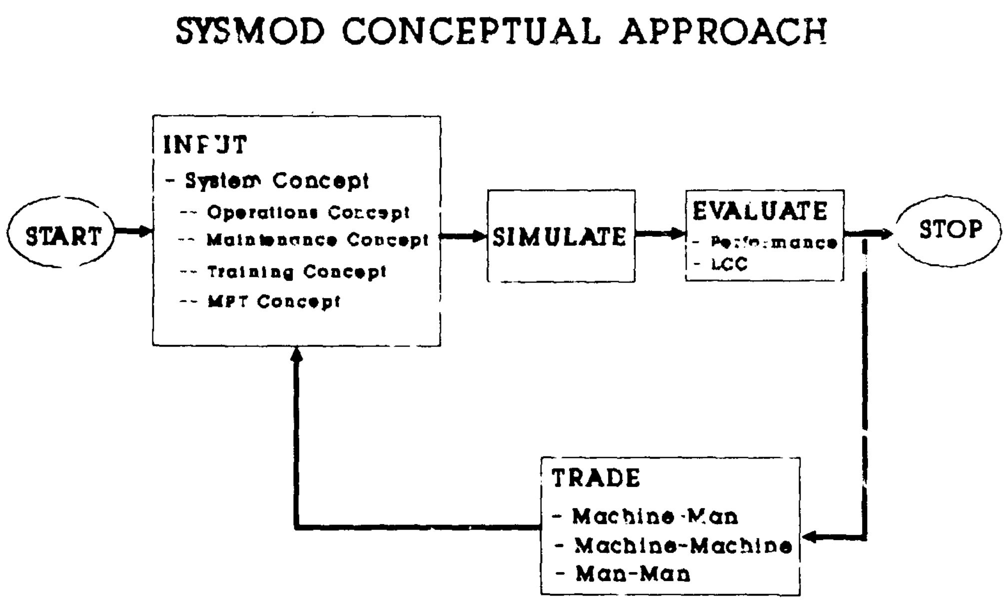

Figure 4

facilitate making trades among operational system characteristics (such as reliability, maintainability, supportability, survivability, etc.), maintenance and logistic concepts, and MPT factors, within specified performance and cost parameters. SYSMOD aggregates micro-level task data to conduct macro-level analyses for the early milestones of the acquisition process [3]. It will share a common BCS architecture with the MPT DSS (as shown in Figure 3) to allow passage of data and design criteria for later validation. A FEA is currently underway to develop the conceptual research plan.

A proposed approach for SYSMOD is shown in Figure 4. The process starts with certain system concepts from a BCS database as Inputs, Simulates their supportability, and then Evaluates the results in terms of performance and LCC criteria. If the weapon system concepts satisfy the criteria, then the process is done and a strategy proposed. If not, then Trades are conducted on three levels and then fed back to the concept stage for adjustment and refinement. The current approach emphasizes a simulation design using a queuing methodology, but some deterministic capabilities may also be needed. Once a microcomputer prototype is developed, SYSMOD will be extensively tested. It will be capable of providing the LCCs of alternate strategies for the Cost and Operational Effectiveness Analyses (COEA) report and the System Operational Requirements & Document (SORD) required as Milestone I products. SYSMOD will provide an integrated tool to develop early MPT criteria in conjunction with other "ility" requirements.

Training Systems for Maintenance. The TRANSFORM project automates the Instructional Systems Development (ISD) to LSAR interface as well as the first three steps of the ISD process. The project takes LSAR design data from contractors, extracts the needed training information, and uses it in the development of training for new emerging or modified weapon systems [12]. TRANSFORM was originally developed for the 3306th Training Development and Evaluation (TDES) Squadron, a part of Air Training Command at Edwards AFB CA. Prior to TRANSFORM the entire process of developing weapon system related training had been a slow, labor-intensive, manual process requiring much repetetive data manipulation.

The automated ISD functions are organized in terms of five user categories: database administration, program manager, ISD analyst, quality assurance reviewer, and reference file maintainer. It includes modules that provide system security, database administration, utilities, communications, and report generation, as well as the ISD analysis core. It uses a VAX minicomputer for LSAR data extraction and a IBM-compatible microcomputer in a local area network (LAN) for the ISD analysis. The analyst can be supported by decision support logic for selecting tasks for training, developing learning objective hierarchies, selecting instructional settings, selecting training media, identifying sequencing instructions, and identifying training equipment fidelity requirements. An audit trail records ISD analysis decisions for later review and modification. The ISD analysis is documented on automated analysis worksheets. This system, which is now operational, became the prototype for a joint service ISD/LSAR Decision Support System which has been applied at several test sites across the three services.

Logistic Composite Model. LCOM is a monte carlo, discrete-event simulation program written in SIMSCRIPT and designed to determine the manpower effects on sortie rates. It contains summarized MDCS data on components of a comparable weapon system for manpower planning. It is frequently used to model aircraft maintenance activities including such resources as spare parts, support equipment, facilities, and personnel. Among other things, it includes information on schedule of sortie demands, component failure rates, and a logical network of required maintenance activities [5]. It is considered the primary manpower planning tool available today in the Air Force, but is very complicated to run on a VAX minicomputer and is very data intensive. Efforts are underway to simplify the model, add personnel and training factors to it, and develop a microcomputer version.

Occupational Research Data Bank. ORDB is an on-line occupational and demographic data repository which is undergoing significant changes to provide the needed data for MPT decision makers and analysts [10]. Every officer and enlisted AFS in the Air Force is represented including information on the people in the occupation. It is organized into seven subsystems: Enlisted AFSC Information Subsystem, Officer AFSC Information Subsystem, Comprehensive Occupational Data Analysis Programs (CODAP) Reports, Enlisted Statistical Subsystem, Computer Assisted Reference Locator, Archived Statistics, and Weapon System Information Subsystem. It contains task performance data on each AFS from the Occupational Survey Report (OSR) file as well as demographic information on each individual airman from the Uniform Airman Record (UAR) file. The statistical analysis compability has changed from an aggregated structure to an individual record structure, thus saving much Sperry mainframe computer space and increasing access time. The weapon system information susbsystem is new and was built to provide occupational and demographic data by weapon system. An officer statistical subsystem will be developed next year, using the Uniform Officer Record (UOR) file. Ongoing enhancements are needed to provide the latest occupational and demographic data for decision makers in the acquisition process.

Weapon System-Specific Job Analysis. The primary problem in the MPT arena within the acquisition process is not the lack of analytical tools, because there are many of them although designed for many different purposes. Rather, the problem is the lack of integrated task-level data bases with which to drive the tools. The data bases being used (maintenance, occupational, logistic, personnel, and manpower) have differing types of data in different formats. The WSSJA project is mapping task statements between different data bases. Currently, using a semantic-assisted analysis technology (SAAT), the MDCS and OSR data bases have been linked [6]. The MDCS holds data on specific maintenance activities for current weapon systems using a five-digit work unit code (WUC) structure. The tasks are identified by the action taken, the crew size, and the start and stop times of the activity. The OSR data files use specific task performance statements organized by AFS. The data includes learning difficulty, training emphasis, percent time spent performing, and percent memebers performing for each task.

A prototype software package has been developed that provides a better than 85% match between these two data bases. Figure 5 is a simplified depiction of the task matching process. The SAAT procedure first examines the data bases for common words, phrases, or concepts (WPCs). The WUCs and task statements are cross-matched based on these WPCs. It then

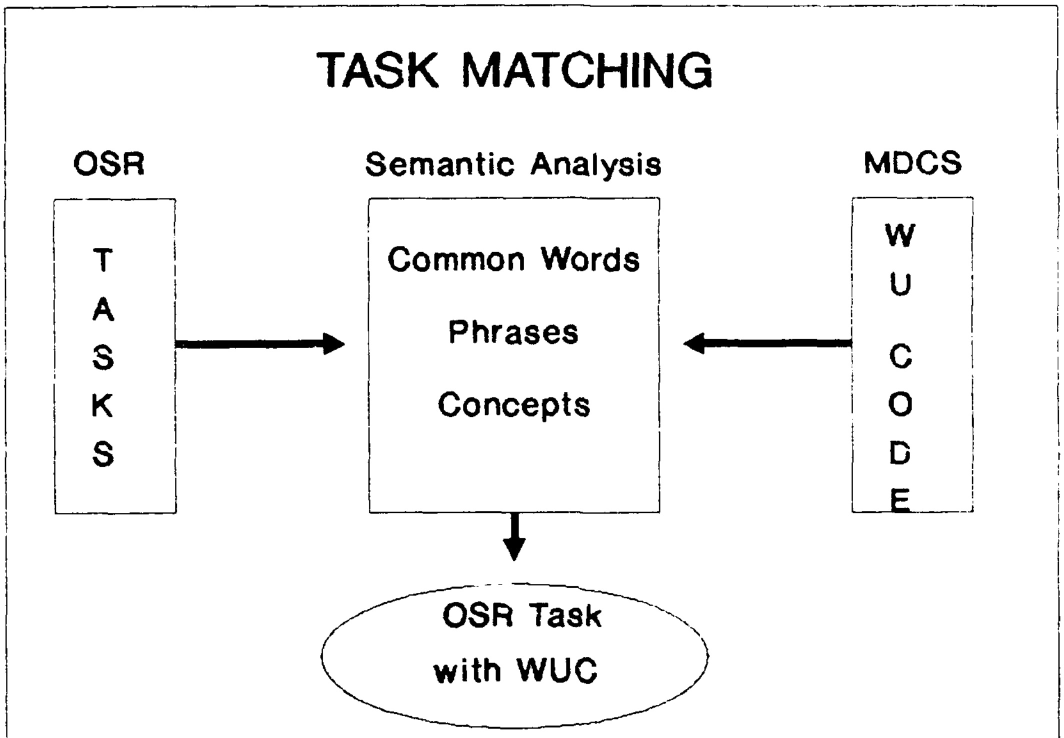

Figure 5

groups similar ideas together and replaces these WPCs with common tokens in an iterative process. Each token is evaluated within the context of its information value. This value is established by comparing the frequency with which a token occurs within a subset of the statements of interest with its frequency of occurrence outside the subset. The next step is to link the MDCS and OSR data bases with the LSAR data structures. In addition, a weapon system oriented task inventory survey process is being developed just like the current occupational survey process by AFS.

JOINT SERVICE COOPERATION

In the 1970s, the Air Force developed two MPT in acquisition analysis tools which were not operationally implemented: ASSET (Acquisition of Supportable System Evaluation Technology) and CHRT (Coordinated Human Resource Technology). In the early 1980s, the Navy used part of these tools to develop a paper-and-pencil analysis capability called HARDMAN. This is also the name of their MPT program and remains the same today as it was ten years ago. The Army modified and automated the HARDMAN tools and called it MIST (Man Integrated Systems Technology). An enhanced version of MIST, called HARDMAN II, is being developed. Meanwhile, the Army Research Institute (ARI) has completed development of a brand new set of MPT analysis tools called HARDMAN III. This consists of six separate tools: SPARC, which sets performance criteria; M-CON, T-CON, and P-CON, which set constraints; and MAN-SEVAL and PER-SEVAL, which evaluate designs. During the past two years, researchers at ARI and ALHRD have been keeping each other informed on their respective MPT projects. With the recent completion of the prototype HARDMAN III tools, and the start of major Air Force MPT development, plans have been made to share data and analysis techniques to ensure compatibility and avoid duplication. The Air Force is preparing to evaluate the HARDMAN III tools for modification and applicability to the Air Force. ARI personnel have agreed to provide consultation to ALHRD. Efforts are also being started to consider a joint service project to examine defficiences in current systems and expand on funding opportunities.

However, there are some major philosophical difficulties that need to be overcome first. The Air Force makes more use of SMEs and detailed task-level data, the AFS structure is a core component of any Air Force model, and emphasis is placed on enlisted maintenance. The Army uses existing empirical data, lacks a training evaluation module in HARDMAN III, and emphasizes operator support. These differences are not preventing a great deal of mutual cooperation and sharing of information.

SUMMARY

To properly insert MPT factors into the acquisition process as required by Congressional law and DoD directive, much analytical research is being undertaken. The Air Force's IMPACTS program is a means of inserting MPT factors into the acquisition of major weapon systems. The Human Resources Directorate of the Armstrong Laboratory is developing the tools, techniques, and data base linkages to assist MAJCOM Planning personnel and SPO analysts to meet these requirements. A comprehensive, coordinated research program is underway within the MPT Technology Branch consisting of eight projects: Specialty Structuring System, MPT Functional Relationships, MPT Decision Support System, Weapon System Optimization Model, Training Systems For Maintenance, Logistic Composite Model, Occupational Research Data Bank, and Weapon System-Specific Job Analysis. These projects will give Air Force decision makers and planning personnel the capability to accomplish their job of providing the best weapon system for the least life-cycle cost. Finally, close cooperation with the Army will avoid duplication and enhance compatibility of MPT tool and model development.

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PROLEGOMENA TO AN ACQUISITION CAREER DEVELOPMENT PARADIGM

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If it becomes desirable to organize any knowledge as science, it will be necessary first to determine accurately those peculiar features which no other science has in common with it, constituting its peculiarity; otherwise, the boundaries of all sciences becomes confused, and none of them can be treated accordingly to its nature.

Immanuel Kant, Prolegomena to Any Future Metaphysics (1783)

ABSTRACT

The need for highly qualified, trained, and educated acquisition personnel -- a professional acquisition workforce -- has been generally recognized by the Department of Defense, the Congress, and various commissions and outside observers. The Department of Defense has long established mandatory training of its contracting personnel and its program managers. Other acquisition specialties have or are developing mandatory training. The Department of Defense has established procedures and a structure for identifying training needs and establishing courses of instruction under the auspices of the Acquisition Career Enhancement (ACE) Program. A concept of orderly career progression has been promulgated in DOD 5000.52-M. The Defense Acquisition Workforce Improvement Act mandates acquisition corps within the Department of Defense; establishes positive qualification criteria for critical acquisition positions in terms of education, training, and experience; and, requires the Secretary of Defense to establish a Defense Acquisition University structure.

To proceed effectively and efficiently requires a conceptual framework or paradigm for acquisition career development that coherently and logically integrates training, education, and experience. This paradigm would be grounded in an understanding of the meaning of acquisition, its relationship to various subordinate career fields and disciplines, a proposed methodology for identifying training objectives, and the role of the Defense Acquisition University structure within the career development paradigm.

This paper cannot provide definitive answers; rather, its purpose is to raise fundamental questions and begin a dialogue within which concrete policies and organization may be established.

INTRODUCTION

On November 5, 1990, President George Bush signed the National Defense Authorization Act for Fiscal Year 1991 (Public Law 101-510). Included in this Act as Title XII is the Defense Acquisition Workforce Improvement Act (DAWIA), a law which has profound implications for the acquisition workforce, and especially the contracting workforce, within the Department of Defense.

The major thrust of the DAWIA is to improve the quality of the defense acquisition workforce by emphasizing the qualifications, training, and personnel management of individuals assigned to acquisition positions. This legislation is intended to effect a cultural change by establishing statutory minimum qualification standards in terms of education, training, experience and career progression. The Secretary of Defense is to ensure "that appropriate career paths for civilians and military personnel who wish to pursue careers in acquisition are identified in terms of the education, training, experience, and assignments necessary for career progression of civilians and members of the armed forces to the most senior positions." (1) It further establishes positive education, training, and experience requirements for assignment to critical acquisition positions via acquisition corps membership and also establishes minimum standards for contracting officers, senior contracting officials, program managers and deputy program managers, Program Executive Officers, and general/flag rank officers and their civilian counterparts. To effectively implement these requirements, the law requires a centralized approach to the education and training of the acquisition workforce. (2) The law also requires that the Secretary of Defense, acting through the Under Secretary of Defense for Acquisition, establish and maintain a Defense Acquisition University structure.

In order to effectively implement the spirit and letter of the new law, a career development paradigm should serve as a frame of reference. It will identify the primary focus of each level of career progression in terms of its content (education, training, and experience) and will link the various levels one to another in an overall structure so that each level prepares the individual for the next level. The paradigm will consider the role of the Defense Acquisition University structure within the context of existing schools.

Before proceeding to establish career paths for acquisition personnel a basic understanding of terms is required. What is the meaning of education, training, and experience and what is their interrelationship to one another? For what purpose do career paths exist and how do they relate to a quality acquisition workforce? What is meant by the terms acquisition and acquisition education and training? What role should the Defense Acquisition University have in the educational development of the acquisition workforce? By clearly and precisely understanding the meaning of these terms within the context of the public policy manifested in the DAWIA one can achieve the goals of that policy and avoid what Max Weber termed the paradox of unintended consequences. (3)

BACKGROUND

The qualifications, training, and personnel management of acquisition personnel has been a matter of long-standing concern to the Executive Branch and to the Congress. In the past, the issues of the professionalism and quality of the acquisition personnel has been subsumed in the larger issue of "acquisition reform" which, historically, tended to focus more on the acquisition process and, to a lesser degree, on acquisition organization. These concerns and the issue of reform gained renewed emphasis with the spare parts "horror stories" of the early 1980s.

Within the Department of Defense, the issue of the training of contracting personnel was elevated to Deputy Secretary of Defense Taft, who on August 19, 1985 directed that a comprehensive review be conducted of the actions needed to promote a more professional contracting, quality assurance and program manager workforce. The upshot of this review was the Acquisition Enhancement (ACE) Program Report which developed experience prerequisites and education and training requirements for 15 job functions. There was a further recommendation that a DOD University of Acquisition Management (DUAM) be established and that a follow-on study of the DOD acquisition training base be conducted. On August 22, 1985 Deputy Secretary of Defense Taft directed that the Military Departments and

Defense Agencies upgrade their procurement training plans to support 85 per cent of their mandatory requirements each year. (4)

In July 1985 President Reagan appointed Mr. David Packard, former Deputy Secretary of Defense, to head a Presidential Commission studying Defense management. The Packard Commission Report was issued in 1986 and found that the acquisition workforce was "undertrained, underpaid, and inexperienced" relative to its industry counterparts and the Report warned: "Whatever other changes may be made, it is vitally important to enhance the quality of the defense acquisition workforce -- both by attracting qualified new personnel and by improving the training and motivation of current personnel." (5) The Report called for greater management attention to the training of acquisition personnel in general and contract specialists in particular, observing that such training should be "centrally managed and funded." (6)

In February 1989, President Bush announced in a Joint Session of Congress that he was directing the Secretary of Defense to develop a plan to "improve the defense procurement process and...develop a plan to accomplish full implementation of the recommendations of the Packard Commission." (7) The result was the Defense Management Review and the Defense Management Report which called, inter alia, for bringing to bear the full talents, dedication, experience and judgement of the DOD workforce. Specifically, this report calls for increasing the "professionalism of its procurement workforce to make its employees' capabilities and career opportunities more competitive with those of their private sector counterparts." (8)

The spare parts horror stories also engendered new interest in acquisition reform within the Congress. The qualifications and tenure of program managers was a matter of concern which led to positive statutory requirements for training, experience, and length of tenure. (9) Sharpened interest in acquisition reform developed in the summer of 1988, following the disclosure of the F.B.I. defense procurement investigation known as "Ill- Wind". The House Committee on Armed Services and its Acquisition Policy Panel, and in 1989, the Investigations Subcommittee began to thoroughly and systematically study the acquisition workforce and review the recommendations previously made. (10)

The upshot of these endeavors by the Investigation Subcommittee was a report which served as the primary frame of reference against which the DAWIA was drafted. This report examined the relevant history of acquisition workforce policies in the Department of Defense and compared those policies and the extant public laws to the effectiveness of their implementation. The report assessed the quality of the acquisition workforce and to review the efforts to "establish and manage the career development of that workforce; and, where appropriate, provide recommendations for improving the quality and professionalism of that workforce." (11)

Based on the analysis of the acquisition workforce within the DOD, the Subcommittee proposed a comprehensive and integrated system for the development and management of professional acquisition personnel within the Department of Defense. A draft legislative proposal was developed and provided to the Department of Defense and to outside experts from industry, academia, the General Accounting Office, and retired senior civilian and military officials of the Department of Defense. (12)

A primary emphasis in the DAWIA is on increased education, training, and qualification requirements. The Secretary of Defense is to establish education, training and experience requirements based on the level of complexity of the duties carried out in the position. There are statutory provisions for positive college-level education, training and experience requirements for acquisition corps members with particular emphasis on the contracting (GS-1102) workforce and contracting officers. (13)

CAREER DEVELOPMENT PARADIGM

To implement the career development provisions of the DAWIA requires a coherent structure which relates education, training and experience to each other; such a structure should be found in a career development program. A conceptual career development paradigm, initially universal, will be explicated and then will be developed within the context of acquisition.

The concept of a paradigm has been chosen vis-a-vis that of the oft-used model because the latter is too restrictive. A model serves to represent reality (or a piece of reality) for various purposes: to allow for prediction of some future events, to test various parameters, to validate hypotheses and so forth. A paradigm, however, is a pattern or exemplar, an explanation of a reality. Thomas S. Kuhn used the concept of paradigms to explain the development of scientific revolutions, conceiving of them as explanations of regnant major theories coupled with their actual practice, from which spring coherent traditions. A paradigm serves as an intellectual, cultural, socio-economic and political frame of reference from which to interpret "facts" thus giving meaning and context to the gathering of facts. It may serve as a vehicle for further refinement and articulation of theories and "facts". (14)

A proposed career development paradigm would comprise the essential elements of learning and development: education, training, and experience. It would say that the correlation and logic of these three elements correctly reflects the reality of intellectual and career growth, and its application should lead to a highly qualified and professional acquisition workforce. It would further place these three elements within the context of their respective and related disciplines, what Mannheim refers to as their "exact modes of knowing", but would also place these disciplines within the context of specific, purposeful, collective action, i.e., the acquisition process. (15)

To develop a meaningful acquisition career development model, one must understand what is meant by education, training, experience, and their relationship. Further, one must comprehend the meaning of acquisition in terms of process and body of knowledge.

Education. Education has several definitions, including the process of nourishing and rearing; of bringing up the young; and the "systematic instruction, schooling, or training given to the young (and, by extension, to adults) in preparation for the work of life."(16) The concept of education presumes the learning of certain basic intellectual skills and the apprehension of knowledge in various disciplines (languages, mathematics, and the sciences). Education provides one the mental tools to function in society. Alfred North Whitehead defined education as "the acquisition of the art of the utilization of knowledge." (17) Education implies the continuous learning by applying various intellectual activities in specific situations. The general educational baseline will allow one the apprehension of specific learning in various disciplines or bodies of knowledge. Thus, at the rudimentary level, one must first acquire fundamental skills, such as reading, which then allows the individual to comprehend new *information*. Thus there exists a generally accepted minimum universal body of knowledge which will provide the recipient the basic cognitive and analytical skills necessary to function in our society and to continue self-education and development. This body or bodies of knowledge comprise the traditional, universal disciplines (in so far as they are understood and accepted by Western Civilization). These intellectual tools serve as the platform or benchmark for the apprehension of more advanced skills in various specified or functional bodies of knowledge such as the law, business, or engineering.

Clearly, education is more than the acquisition of facts. Rather its purpose is to assist the individual in living. This leads to the essential point that education has to include more than the accretion of knowledge and the ability to think; but it is also value-laden. Education must also inculcate the values of the society or culture and provide the individual the means of assimilating and applying those values in the world.

There are two salient characteristics regarding education. The first applies to education as a learning process. Education is a dynamic process; this means that we learn differently at stages of our life, based on our intellectual maturity. Whitehead discussed the stages of mental growth or "the rhythm of education." Bloom referred, comparably, to the major categories in the cognitive domain. These would consist of knowledge, comprehension, application, analysis, synthesis, and evaluation. (18) The second characteristic of education is the exponential growth in the depth of the general body of knowledge in terms of sheer numbers of facts, complexity and diversity. This trend is even more pronounced in the proliferation of professions, which is the result of specialization. "The expert, not the cultivated man, is the educational ideal of a bureaucratic age." (19) One upshot is the continued acceleration in knowledge in all fields. This is particularly the case in the areas of science and technology, which have had profound affects on the growth of knowledge in related engineering, scientific, and management fields while spawning new disciplines such as systems engineering. (20) The result is an explosion in multiplicity of knowledge without unity. Paradoxically, with the growth of specialization comes the need for integration of various disciplines into coherent and meaningful relationships. As we shall see, this is the role for acquisition as a body of knowledge.

Training. Whereas education conveys a general or universal application, training denotes specificity. An early definition of the word to train was "to undergo or follow a course of instruction and discipline." A similar definition is to "instruct and discipline in or for some particular art, profession, occupation, or practice." (21) There is a blurring of the distinctions between education and training so that the terms are often used interchangeably. Thus to understand what each entails requires an analysis, arbitrarily drawn to some degree, of their distinguishing characteristics. One defining distinction is not on what or how you learn but on where you learn. One connotes education with formal schooling in a "educational" institution, a college, university or professional school. Training, conversely, would be received in a different environment -- at a job site, in an office. Another difference is in the duration: education is regarded as a lengthy process; training tends to be regarded as short term. The orientation of education, at least at the basic level, is on the comprehension of universal intellectual skills. Building on these basic skills or first principles functional knowledge in various disciplines is acquired. This knowledge may be applied in various situations within its particular intellectual environment. Training tends to focus on the immediate and practical. Its application tends to be more situation specific with an emphasis on action: what to do and how to do it. The education supporting this application of a skill would do two things. First, it would provide the basic cognitive domain skills to properly learn the training at hand. Second, it would provide an environmental context that would promote understanding of why this specific action is being undertaken.

The distinctions between education and training may be summarized in terms of their purpose, scope, expected outcomes, and the time frames involved. Education emphasizes the development of systems for new information processing and provides the knowledge, skills and values needed for successful living within the society and culture of the individual as well as the ability to deal effectively with new information and changing conditions. Training focuses on acquiring limited, job-related skills and provides specific skills, knowledge, or attitude needed to meet organizational goals. The outcome of education will be individuals who continuously acquire and effectively process new information, whereas the outcome of training will be individuals who can perform specific tasks to specific standards to meet established goals. In terms of scope, education deals with a complex set of attitudes, skills, and values and training deals with specific tasks. With regards to the timeframes, education is oriented on the long-term -- a lifetime -- whereas training is oriented towards current needs and immediate applications. (22)

Experience. Experience may be considered as the application, the concretization, of education and training in specific and purposive situations. Unlike Descartes' dichotomy between the "world of books" and the "book of the world," experience is the transformation of the world of books into the book of the world. Fundamentally, experience is characterized by action, by doing. However, action without purpose or meaning is not the type of experience we need. Rather, the actions of acquisition personnel must be grounded in sound principles applying the various tools and techniques learned in the education and training environments of the career development model. Experience serves to reinforce in concrete terms what one has learned in the abstract. Not only will the experience reinforce the learning, but it should validate that which was learned -- does this work or is there a better method. Experience is the cement that binds the body of knowledge or discipline to the individual and is indispensable to career progression and intellectual growth. Without experience, the education and training would be sterile. As one progresses to higher levels of responsibility, the equation of the relative cognitive domains shifts from knowledge to analysis and ultimately to synthesis and evaluation. At the more senior levels, the intellectual demand will be for judgment, which must be learned. The relationship between judgment and experience was best expressed by Robert A. Lovett during the Cuban missile crisis: "Good judgment is usually the result of experience. And experience is frequently the result of bad judgment." (23)

IN SEARCH OF THE PARADIGM

Education, training, experience, and self-development are not only interrelated, but must be mutually reinforcing. The career progression paradigm must rest on four pillars: education, training, experience, and self-development. What, however, is the logic that ties these three activities together in a meaningful whole? An analogue for this paradigm may be found in the realm of cognitive science which seeks to explain, inter alia, the physiology of the brain and thinking. In understanding how one thinks, acts, and remembers (certainly the function of memory is key to education and training), it has long been recognized that one remembers not by exact repetition, not linearly and immediately but indirectly and through reprocessing of information. Freud recognized this as early as 1896 when he posited the concept of categories when he wrote that "memory is present not once but several times over...People are never exactly what they were moments before and objects are never seen in exactly the same way." (24) Cognitive scientists have developed the concept of "recategorization" to explain this phenomena.

> Recategorizations occur when the connections between the neuronal groups in different maps [of the brain] are temporarily strengthened.
>
> Recategorization of objects or events is a skill acquired in the course of experience. We recollect information in different contexts; this requires the activation of different maps interacting in different ways from those of our initial encounter with the information and it leads to recategorization. We do not simply store images or bits but become more richly endowed with the capacity to categorize in connected ways....Human intelligence is not just knowing more, but reworking, recategorizing, and thus generalizing information in new and surprising ways. (25)

What this means for our career development paradigm is that we are constantly recategorizing what we have learned in terms of the universal educational body of knowledge or corpus, specific academic and professional disciplines and training received in terms of its application in real-life. The experience of real-life revalidates the body of knowledge and, in the process, transforms it into something ever new. Thus the paradigm of career development must recognize the distinctive contributions of education, training, and experience and their ineluctable connectivity. Thus, distinctive and related career paths must serve as "maps" that preserve the patterns of relationships between education, training, and experience. These career patterns should recognize the unique and distinctive contributions that each element makes in the various stages of development.

There are two basic components in the inextricably linked equation. On the one side is experience. Here the functional and personnel management must insure that individuals receive the kinds of job experiences for which they are prepared and qualified, based on their training, education, and prior experience. No one should be placed into a position for which they lack the skills to perform effectively. Everyone should be given the opportunity to demonstrate the skills that they have acquired and to validate their knowledge and ability through the job opportunities available to them. This is basically an administrative function of management. On the other side of the equation are the education and training institutions which provide the intellectual tools and basic knowledges required. This educational environment has two components. First, there are the private sector colleges, universities, and professional schools which will provide the various types of education required for the acquisition workforce. Most of this education should be provided, as a minimum, prior to entry into the acquisition workforce. However, this educational environment will remain available to individuals throughout their careers. The second educational environment is the Defense Acquisition University within the Department of Defense. It is here that the blending and galvanizing of prior civilian education and experience will be given a specific educational and training application required of defense acquisition managers. Lastly, there is the individual who over time bridges both environments in his or her career progression. This progression is not linear but a spiral ever forward; it is a series of steps or plateaus where one validates the knowledges previously learned through experiential application. But it is essentially self- development and self-cultivation, akin to the German concept of Bildung.(26)

The foundations for this career development paradigm exist in DOD 5000.52-M, "Career Development Program for Acquisition Personnel," which was promulgated in September 1990. Nonetheless, this Manual contains the basic elements and structure for an effective career management system. It organizes the acquisition workforce into the three essential elements of a career development paradigm: career fields ("one or more occupations or functions that require similar basic knowledge and skills"), career levels ("groupings by a range of grade levels...that provide the framework for overall training, planning and progression within a career field"), and career patterns ("the range of opportunities at each level and the optimum pathways for vertical and horizontal movement within a career field"). Thus all the conceptual building blocks for developing the paradigm are there. To integrate and administer these elements coherently requires two additional ingredients: career programs and career management. A career program is "comprehensive operating plan for administering a career field" and career management is a "continuing process by which employees in specific career fields" are managed. (27) It also recognizes the levels of career development as is indicated in Figure 1. The Manual identifies nine different career programs. The Defense Acquisition Workforce Improvement Act envisions eleven major functional categories.

Acquisition. In order to establish properly the education, training and career development requirements for acquisition, one must first clearly understand the meaning of the term "acquisition" and describe what might constitute its body of knowledge or intellectual corpus. DOD Directive 5000.52 defines acquisition as the "conceptualization, initiation, design, development, test, contracting, production, deployment, and logistics support of weapon and other systems, supplies, or services (including construction) to satisfy Agency needs, intended for use in or in support of military missions."(28) This is truly an all-encompassing cradle-to-grave definition. Juxtaposed against this is the more encompassing definition of acquisition in the Federal Acquisition Regulation:

"Acquisition" means the acquiring by contract with appropriated funds of supplies or services (including construction) by and for the use of the Federal Government through purchase or lease, whether the supplies or services are already in existence or must be created, developed, demonstrated, and evaluated. Acquisition begins at the point when agency needs are established and includes the description of requirements to satisfy agency needs, solicitation and selection of sources, award of contracts, contract financing, contract performance, contract administration, and those technical and management functions directly related to the process of fulfilling agency needs by contract.(29)

J. Ronald Fox points out that the term acquisition came into vogue in the 1980s over the terms defense procurement and defense R & D management, which were previously used. Fox defined acquisition as "the process of developing and producing defense systems -- usually weapon systems." (30)

In reality, it is more appropriate to posit two definitions of acquisition: one is broad in scope but narrow in application, the other is broad in application but narrow in scope. The first is applicable to systems acquisition and contains the general meaning found in the DOD Directive 5000.1. This is the definition of "systems acquisition." This definition is broad in scope in that it encompasses many different specific disciplines involved in the systems acquisition process, involves a highly structured decision-making process, and has its locus in organizations whose raison d'etre is systems acquisition. The second definition is more appropriately entitled "acquisition" and is based on the meaning in the Federal Acquisition Regulation. It approximates the meaning found in the old term "procurement." The contracting process inheres in this definition as does production, and quality assurance. This process comprises a vital, integral part of the systems acquisition process. Yet it also exists independently of the systems acquisition process and has application at all levels where the Government requires goods and services from the private sector. The distinguishing characteristic of acquisition is the interface with the private sector as only "the defense industry produces war materiel." (31)

Acquisition is more, however, than a process. It consists of the organization and people who execute the process. This is the key to understanding the relationship between acquisition as a discipline or body of knowledge and the acquisition workforce. The acquisition workforce consists of personnel in numerous career fields or disciplines who are part of acquisition in two particulars: first they may be a part of acquisition because their specific discipline is an ipso facto acquisition discipline, such as contracting, or the particular mission of their organization requires the application of the knowledge, skills and abilities of their specific discipline in support of the acquisition process. Thus, their discipline's body of knowledge has an acquisition application. In addition, there is an acquisition discipline or body of knowledge, that has been evolving from the traditional field of project or program management. This body of knowledge has served the function of program integration, i.e., the binding together of all these disparate disciplines for the purpose of systems acquisition. A military metaphor that may help to clarify this relationship between acquisition and the various autonomous disciplines is that of the combined arms team in military operations: the integration of airpower, artillery, armor and infantry into a cohesive team to accomplish specific missions. Thus a description of acquisition as a body of knowledge is a high-level integration of various sub-semi-autonomous-disciplines for the purpose of acquiring products or services -- the transformation of a need or requirement by the private sector for use by the government. Generically, acquisition may be thought to comprise all these specific disciplines organized for a specific purpose. At another level, however, there is a more precise definition of acquisition (as a discipline) which may convey the true meaning. Relying again on the combined arms metaphor: the acquisition body of knowledge is similar to that of command and control (how the various military elements are organized and controlled to accomplish the mission) in that it organizes the various semi-autonomous disciplines and integrates their activities for a common purpose. (32)

THE DEFENSE ACQUISITION UNIVERSITY STRUCTURE

The Defense Acquisition Workforce Improvement Act requires the Secretary of

Defense to establish and maintain a Defense Acquisition University "structure" to provide for the professional educational development and training of the acquisition workforce and perform research and analysis of defense acquisition policy issues from an academic perspective. Administratively, this University should achieve more efficient and effective use of available acquisition resources by coordinating DOD acquisition education and training programs and establish lines of authority and accountability between the various acquisition educational institutions within the Department of Defense. It further calls for an appropriate centralized mechanism under the Under Secretary of Defense for Acquisition to control the allocation of resources for the conduct of training, educational programs, and the payment of instructor salaries. The University will also be responsible for establishing a coherent framework for the educational development of acquisition personnel. (33)

In developing the new Defense Acquisition University, what guiding principles, or terms of reference, should be used? What should be the relationship of the cognizant bodies of knowledge and existing Department of Defense training infrastructure to this new structure and to what degree should these elements be related to the career development paradigm?

The Department of Defense Professional Military Education (PME) program may serve as an analogue for the Defense Acquisition University and its educational system. In 1989 the Panel on Military Education of the House Armed Services Committee surveyed the extant PME system and found a piecemeal structure. A similar, disparate and fragmented structure exists today within the Department in terms of the acquisition education and training provided. This is shown by Figure 2 which reflects the various sponsoring schools, certified schools and certified course offerors involved in the mandatory acquisition training. Table 1 indicates the number of current ACE courses, the applicable career field and the various offerors.

In response to its findings, the Panel posited a conceptual framework for PME schools that may serve as guiding precepts for Defense acquisition education. There are four guiding principles in this framework. First, it identifies the levels of professional schooling, e.g., primary, intermediate, senior, and flag/general officer. Second, this framework should clearly and distinctly establish the primary focus of each level in terms of its primary teaching objectives. Next, the framework links the education levels together into an overall structure, relating the principal teaching objectives so that each level of school prepares officers for the next level as they progress through the system...[and lastly]...the framework identifies the unique contributions of each school within its level. The resulting framework should clearly distinguish and relate the primary focus of each of the...schools. (34)

The focus on teaching objectives must be clear and distinct. The Panel on Military Education called for clear and distinct primary teaching objectives that clarifies the purpose of the learning at each level, ensures coherence so that succeeding levels build on the foundations of earlier schools, and avoid unnecessary overlap. It called for a "clear and coherent conceptual framework for the...school system. The framework should have distinct primary teaching objectives. It should clearly distinguish and relate the role of each of the...schools plus...courses. Each level of schooling and each school should have a primary focus that provides students with a foundation for future growth through experience and...assignments and through additional education at high-level...schools." (35)

The Defense Acquisition University must not only be effective and efficient in fulfilling its missions, it should serve as a center of excellence for the development of acquisition professionals and it should be an integral part of the acquisition structure within the Department. This means that the faculty should be the best and brightest. Not only should some of the faculty come from industry and academia as recognized experts in either theory or practice, but it should also draw from the very best civilian and military acquisition professionals. A three or four year tour on the faculty should be recognized as an important step in career progression to senior acquisition management levels. There must be rigor in the standards and curriculum. For the more senior educational courses such as the Program Management Course and a new senior level course to be developed, nominees must be accepted based on strict standards of demonstrated ability and qualifications (education, experience, and previous training). All courses should include examinations and the senior level courses should include relevant research projects and essay examinations. A focus of the research should be on the further development and articulation of acquisition doctrine and its relationship to the various disciplines comprising acquisition. Graduation from the mandatory DAU courses must be a sine qua non for career progression in acquisition. Secretary of Defense Fellowships should be an integral part of the DAU structure for the purpose of advanced study in appropriate fields of study at the most prestigious universities in America. (36)

Similar to the PME, there needs to be a rational determination of the "center of gravity" in the curricula on which each level of schools can concentrate. Like PME, professional acquisition education should consist of levels of education related to the duties and status of the individual concerned to assure their qualification is commensurate with their responsibilities. At the primary level, the emphasis should be on basic and advanced training in various acquisition disciplines; it should be related to the skills required to perform the duties at that level. The goal should be technical proficiency. At the intermediate level, the focus should be on interrelationships of various sub-disciplines and their organizational context. The focus should shift to an emphasis on development of analytical capabilities and integrative thought processes. At the senior level, the emphasis should be on increased understanding of acquisition management of the various components or sub-disciplines of acquisition and their interrelationship to defense management, to the requirements process, operational art and national defense and national security strategy formulation. The focus should be on the macro-level political, social, and economic forces that influence the acquisition process. Professional acquisition education, like PME, is "not a lock step progression, but rather a continuum that embodies the levels and kinds of military education that broaden the perspectives and produce more capable officers." (37)

CONCLUSIONS

Career development is not linear, but rather akin to a journey to ever-increasing hierarchical levels of responsibility and accountability that are correlated to different modes of decision-making supported by varying modalities of thought. The proposed career development paradigm seeks to integrate training, education, and experience within the acquisition bodies of knowledge and organization. It proposes that the Defense Acquisition University Structure be an integral part of acquisition and complement the experiential opportunities provided through the personnel management process by training and educating acquisition professionals in conjunction with higher education in America.

ENDNOTES

1. National Defense Authorization Act for Fiscal Year 1991, Chapter 87, Section 1722(a).

2. Ibid., Subchapter IV, Sections 1741 through 1745. Included under the penumbra of education and training are provisions and requirements for intern programs, cooperative education and scholarship programs as well as the allowance for educational tuition reimbursement and training for current employees in acquisition positions.

3. Reinhard Bendix, Max Weber: An Intellectual Portrait, Garden City, New York: Anchor Books, 1962. Bendix quotes Weber in describing the "strange reversion of the 'natural'" relation between what men intend by their acts and what actually comes of them. In his Religion of China Weber was explaining the paradox of rationality by comparing the intentions and outcomes of Puritanism and Confucianism. "In China, material welfare was exalted above all other goals in life and the political and economic teachings of Confucianism deliberately sought to maximize the well-being of the people. Yet in the absence of the appropriate economic mentality Chinese economic policies did not achieve this end. Puritanism, which rejected the pursuit of wealth as an end, unintentionally helped create an economic mentality and a methodical way of life that led to an increase of wealth and jeopardized true religion, as Wesley pointed out." (Bendix, pp. 139-140.)

4. A three month joint review was conducted by the ACE Study Group under the auspices of the Defense Systems Management College, with representatives from the Military Departments and the Defense Logistics Agency. This group also drafted new Defense Directives and Instructions to establish the increased training requirements. One impetus for improving training of procurement personnel came from the Department of Defense Inspector General which reported in early 1984 that 67 per cent of the intermediate and senior level contracting civilians at 24 DOD activities had not completed 67 per cent of their required contracting courses. (Report on the Audit of Department of Defense Procurement Training, No. 84-047, February 14, 1984).

5. President's Blue Ribbon Commission on Defense Management, A Quest for Excellence: Final Report to the President, June 1986, pp. 66-67.

6. Ibid., p. 69. It called for establishing minimum education and/or experience requirements for the contract specialist (GS-1102) series and an entry-level criterion of 24 hours of business-related courses or equivalent experience. It further called for government sponsorship of graduate instruction in acquisition management "to facilitate greater professionalism among civilian acquisition employees." (p. 68) In July 1987, Mr. Packard wrote to President Reagan providing a progress report on Packard Commission recommendations. It was noted that personnel reform was still lacking. One of the 14 recommendations requiring further action to continue action underway "to increase training and professional qualifications of Defense acquisition personnel." (Letter from David Packard, 10 July 1987, to the President, with Attachment).

7. Secretary of Defense, Defense Management Report to the President, July 1989, p.1.

8. Ibid., p. 13; p. 3.

9. In 1985 Congress enacted the Defense Procurement Improvement Act (P.L. 99-145) requiring the Secretary of each Military Department to "prescribe regulations establishing requirements for the education, training, and experience of any person assigned to duty as the Program Manager of a major defense acquisition program" (10 U.S.C. 1622). Previously, Public Law 98-525, enacted on October 19, 1984, required that the tour of duty for newly appointed program managers of major defense acquisition programs be four years or until completion of a major program milestone. This was followed in November 1986 by passage of the Defense Acquisition Improvement Act of 1986 (P.L. 99-661). Section 932 of this Act required the Secretary of Defense to develop a plan to enhance the professionalism and career opportunities available to acquisition personnel. In May 1987 the Secretary of Defense's plan was submitted to Congress, consisting of two initiatives. First, it proposed the establishment of an alternative personnel management system based on the China Lake pilot project. Second, it proposed to improve the education of contracting civilians by modifying Title 5 U.S.C. Section 3308 to allow the Office of Personnel Management and the Department of Defense to establish appropriate minimum educational standards for the contracting series (GS-1102) and to revise Title 5 U.S.C. Section 4107 to allow government payment for training for civilians for the primary purpose of obtaining an academic degree. As a corollary, Section 934 of the Defense Acquisition Improvement Act required the Secretary of Defense to submit to Congress a report containing a plan for the coordination of DOD educational programs for acquisition personnel. In March 1988, the Assistant Secretary of Defense (Force Management and Personnel) submitted a plan for expanding the role of the Defense Systems Management College to properly direct, support and coordinate the education an d training of the acquisition workforce. This plan institutionalized the former Acquisition Enhancement (ACE) Program Action Group into the ACE Program Office at DSMC, designating it as the executive agent for the education and training of the acquisition workforce.

10. The House Committee on Armed Services commissioned a compilation of the previous major commissions defense acquisition in 1988. The Committee observed that there were four major recurring issues: professionalism of acquisition personnel, streamlining of acquisition regulations, the revolving door, and acquisition organization. (House of Representatives, Committee on Armed Services, Defense Acquisition: Major U.S. Commission Reports (1949-1988), Vol I, Committee Print No. 26, 100th Congress, 2d Sess, 1988.) In 1989 the Subcommittee on Investigations examined the British and French acquisition systems, including their organization and personnel management. Both countries had a more centralized and independent (from the operational customer) acquisition organization. In France particularly, it was manifest that the corps of armament engineers assigned to the Armaments Directorate constituted an elite body of well- educated, highly trained professionals. These engineers had a separate personnel system with different rules and pay scales and were promoted on the basis of their engineering and managerial skills. While recognizing the distinctive difference between the United States on one hand and France and Britain on the other in terms of the scale of the defense effort, the structural difference in the respective defense sectors of each nation's economy, the cultural distinctions

and historical traditions of their respective military and civil services, it was clear that a separate professional career track in acquisition, clear lines of accountability, and concomitant authority to the political leadership in each country had merit worthy of consideration. (House of Representatives, Committee on Armed Services, Subcommittee on Investigations, A Review of Defense Acquisition in France and Great Britain , Committee Print No. 5, 101st Congress, 1st Sess, August 16, 1989.

11. House of Representatives, Committee on Armed Services, Investigations Subcommittee, The Quality and Professionalism of the Acquisition Workforce (Print No. 10, May 8, 1990) p. 65. The primary focus was on Program Managers and contracting personnel, both civilian GS-1102 contracting personnel as a career field and their military counterparts and Contracting Officers. It examined the role of the Contracting Officer in the acquisition process, the relationship of the Contracting Officer to the Program Manager, with engineers, attorneys, auditors, competition advocates and with source selection authorities. It found that there were disparate standards, qualifications, and procedures for appointing contracting officers within and among the Military Departments and the Defense Agencies. It also found varying degrees of focus and accountability in managing the contracting workforce among the Departments. It found that there were many Contracting Officers outside the contracting career fields who would not meet the minimum qualifications for training and experience required of contracting personnel. It acknowledged the need for greater focus and centralization in managing the mandatory acquisition training program under ACE. It also noted that the need for a college degree and/or 24 hours of academic credit in business or a related career field had been a goal of the Department of Defense for a number of years but that a lack of statutory authority precluded this requirement for taking effect. The report found that each service was attempting to develop a career program structure, but there were significant variances between services and among the programs for civilians and military officers.

Another follow-on report was issued in the summer of 1990 that focused exclusively on the problem of tenure of program managers of major defense programs, noting that the Military Departments had consistently failed to comply with the length of tenor requirements in public law. (House of Representatives, Committee on Armed Services, Investigations Subcommittee, Life Is Too Short: A Review of the Brief Periods Managers of Major Defense Acquisition Programs Stay on the Job, Committee Print No. 12, July 4, 1990.)

12. House of Representatives, Committee on Armed Services, Investigations Subcommittee, "Proposal for the Creation of a Highly Professional Acquisition Workforce and Acquisition Corps Within Each of the Military Departments (Draft)," March 8, 1990. Subsequently, two hearings were conducted. The first was held on March 28, 1990 to discuss the status of the Defense Management Report and the current legislative proposal. Testimony was received from the Under Secretary of Defense (Acquisition), Service Acquisition Executives, Commander of the Defense Contract Management Command, and Commandant of the Defense Systems Management College as well as Congressional testimony, an outside expert, and the General Accounting Office. Another hearing was held on April 24, 1990 in which testimony was received from five outside experts and former Defense officials: David Packard, Norman Augustine, J. Ronald Fox, Richard Godwin and Robert Costello. (House of Representatives, Committee on Armed

Services,, Hearings Before the Investigations Subcommittee, Acquisition Workforce, H.A.S.C. No. 101-71.)

13. After October 1, 1993 there are positive requirements for Contracting Officers above the small purchase threshold. These include the completion of all mandatory contracting courses required for a contracting officer at the grade level that the person is serving in, a minimum of two years experience in contracting, and a baccalaureate degree, 24 semester hours credit hours of study from an accredited institution in the following disciplines: accounting, business finance, law, contracts, purchasing, economics, industrial management, marketing, quantitative methods, and organization and management; or have passed an examination considered by the Secretary of Defense to demonstrate the skills, knowledges, and abilities comparable to those an individual who has completed 24 semester credit hours would have attained. Lastly, Contracting Officers will have to meet any additional requirements established by the Secretary of Defense based on the dollar value or complexity of the contracts awarded or administered. The same educational requirements apply to civilians in the GS-1102 occupational series. However, there are two general categories of exceptions. First, the positive educational requirements shall not apply to employees who, on October 1, 1991, have at least 10 years of experience in acquisition positions or comparable experience. Second, the requirements will not apply to any employees for the purpose of qualifying to serve in the current position (as of October 1, 1993) they are in or for comparable positions at the same grade involving the same levels of responsibility. The provisions applying to both Contracting Officers and to GS-1102 personnel may be waived by the cognizant acquisition career program board if the board "certifies that the employee possesses significant potential for advancement to levels of greater responsibility and authority, based on demonstrated job performance and qualifying experience." (Section 1724 [d])

14. "In its established usage, a paradigm is an accepted model or pattern, and that aspect of its meaning has enabled me, lacking a better word, to appropriate 'paradigm' here. But it will shortly be clear that the sense of 'model' and 'pattern' that permits the appropriation is not quite the one usual in defining 'paradigm.'...In this standard application, the paradigm functions by permitting the replication of examples any one of which could in principle serve to replace it. In a science, on the other hand, a paradigm is rarely an object for replication. Instead, like an accepted judicial decision in the common law, it is an object for further articulation and specification under new or more stringent conditions." (Thomas S. Kuhn, The Structure of Scientific Revolutions, 2nd Edition, Chicago: University of Chicago Press, 1970, p.23.) Kuhn discusses paradigms within the context of accepted theories and practices. For further discussion see Frederick Crews, "In the Big House of Theory," New York Review of Books (Vol. XXXIII, No. 9, May 29, 1986) p. 39. Fred Dallmayr equates a paradigm to a "fixed thought system." ("Rethinking the Political: Some Heideggerian Contributions," Review of Politics, Vol. 52, No. 4 (Fall 1990), p. 525. A model has been described as "any simplified representation of the real world that enables a better understanding of the world, that helps anticipate how the world is going to react, and better enables communication of the world to others." (U.S. Civil Service Commission, A Training Cost Model [Washington, 1972], p. 3 quoted in David L. Norman, "The Development of a Microcomputer Financial Model for the Management of Variable Training Costs," [Orlando: Training Performance Data Center, August 1988], p. 4.) Also see H.K.

Berg, W.E. Boebert, W.R. Franta, and T.G. Moher, Formal Methods of Program Verification and Specification (Englewood Cliffs, New Jersey: Prentice-Hall, 1982), pp. 8 ff.

15. Karl Mannheim, Ideology and Utopia: An Introduction to the Sociology of Knowledge, (London: Routledge and Kegan Paul, Ltd, 1966), pp. 1 and 3.

16. The Oxford Universal Dictionary, 3rd Ed., Oxford: The Clarendon Press, 1964, p. 584. The word education comes from the Latin educaten, literally a "drawing out" from the individual.

17. Alfred North Whitehead, The Aims of Education and Other Essays, New York: The New American Library, 1958, p. 16. The essence of this concept may be caught in Whitehead's dictum that there "is only one subject-matter for education, and that is Life in all its manifestations." (p. 18.)

18. Educators regard domains as specific areas of learning and specify learning objectives in three domains according to the Military Education Policy Document (Office of the Chairman The Joint Chiefs of Staff, Washington, DC, 1 May 1990 [CM 344-90]). The psychomotor domain deals with acquiring physical skills requiring dexterity, coordination, and muscular activity; the cognitive domain concerns acquiring knowledge or concepts and the development of understanding; and the affective domain concerns the development of attitudes or values. Comparable to Bloom's first category would be what Whitehead called the "stage of romance," that is, the first apprehension of facts where the "subject-matter has the vividness of novelty...it holds within itself unexplored connexions with possibilities half- disclosed by glimpses and half-concealed by the wealth of material....knowledge is not dominated by systematic procedure." (op. cit., p. 29.) This is followed by the "stage of precision" where facts are formulated in exactitude; this is a period of analysis. Lastly comes the "stage of generalisation" which Whitehead compares to Hegel's synthesis.

19. Max Weber, op. cit., p. 430.

20. Modern technology has become in large part the technology of organization, which has transformed social and economic institutions as well as ideas. A distinguishing characteristic of modern technology is the emergence of procedural systems such as systems engineering, systems analysis, and computer technology. For further discussion, see N. Bruce Hannay and Robert E. McGinn, "The Anatomy of Modern Technology: Prolegomenon to an Improved Public Policy for the Social Management of Technology," Daedalus, Vol. 109, (Winter 1980), pp. 25-53 and Daniel Bell, The Coming of Post-Industrial Society: A Venture in Social Forecasting (New York: Basic Books, 1973)

21. Oxford Universal Dictionary, p. 2227.

22. Vincent A. Miller, The Guidebook for International Trainers In Business and Industry, American Society for Training and Development, New York: Van Nostrand Reinhold Company, 1979, p. 3.

23. Richard E. Neustadt and Ernest R. May, Thinking In Time: The Uses of History for Decision-Makers, New York: The Free Press, 1986, p. 11.

24. Israel Rosenfield, "Neural Darwinism: A New Approach to Memory and Perception," New York Review of Books, (Vol. XXXIII, No. 15) October 9, 1986, p.21.

25. Ibid., p.27. For more on this concept, see Bernard Williams, "Leviathan's Program," New York Review of Books,

(Vol. XXXIV, No. 10) June 11, 1987, pp. 33-35; John Maynard Smith, "What Can't the Computer Do?" New York Review of Books (Vol. XXXVII, No. 4) March 15, 1990, pp. 21-25.

26. For the concept of Bildung, see W. H. Bruford, The German Tradition of Self-Cultivation: 'Bildung' From Humboldt to Thomas Mann, Cambridge: Cambridge University Press, 1975. The German tradition of Bildung focuses on the cultivation of the inner-self and implies an "individualistic cultural conscience; consideration for the careful tending, the shaping, deepening and perfecting of one's own personality or...justification of one's own life...(p. vii.)

27. DOD 5000.52-M, "Career Development Program for Acquisition Personnel," October 1990, p. vi. The definition of a career program entails "work force analysis; forecasting and planning; and the systematic selection, development, assessment, utilization, and retention of employees." Career management includes the identification and development of employees in specific career fields, administered through a formal program, and their "assignment and selection to fill positions of increasing responsibility in the Department of Defense."

28. DOD Directive 5000.52, "Defense Acquisition Education and Training Program," August 22, 1988, p. 2.

29. Federal Acquisition Regulation, p. 2-1.

30. J. Ronald Fox, The Defense Management Challenge: Weapons Acquisition (Boston: Harvard Business School Press, 1988), p. 1. A clearer understanding of the term can be gathered if one returns to first principles and delineates between acquisition and major systems acquisition. For most of this century the term "procurement" was used to describe what constitutes acquisition. With the development of project and program management in the 1950s and 1960s a parallel management system was established for the development and purchase of weapon systems. In the 1970s the Armed Services Procurement Regulation (ASPR), written to implement the Armed Services Procurement Act, was changed to the Defense Acquisition Regulation. In response to the Commission on Government Procurement recommendations, the Office of Management and Budget issued OMB Circular A-109, Major Systems Acquisitions, in April 1976. The Circular defined the "system acquisition process" as the "sequence of acquisition activities starting from the agency's reconciliation of its mission needs, with its capabilities, priorities and resource, and extending through the introduction of a system into operational use or the otherwise successful achievement of program objectives." (OMB Circular A-109, "Major System Acquisitions," April 5, 1976, p. 3.) Significantly, the Armed Services Procurement Regulation and its successor, the Defense Acquisition Regulation, did not define acquisition. Rather, it defined the term "procurement" to include "purchasing, renting, leasing, or otherwise obtaining supplies or services. It also includes all functions that pertain to the obtaining of supplies and services, including description (but not determination) of requirements, selection and soliciation of sources, preparation and award of contract, and all phases of contract administration." (Defense Acquisition Regulation, 1-201.13, 15 December 1983)

31. Edward Hirsch, "Defense Acquisition: What Is, What Ought Be, and the Transform", (manuscript, April 1989), p.1. J. Ronald Fox emphasizes this point. "The functions of Defense Department managers of large acquisition programs are not those classically associated with the term

'manager.'...This is because the Defense Department does not develop or produce its weapons systems in-house. The actual development and production work is contracted for, through prime contractors. Hence the principal functions of the program manager and staff are planning, contracting, monitoring, controlling, and evaluating the technical performance of contractors and the government agencies that provide service and support." (J. Ronald Fox, "Obstacles to Improving the Defense Acquisition Process," National Security Program Discussion Paper Series 89-01, 1989, pp. 4-5.

32. Bodies of knowledge then are grounded in the values and organization of their societies, what Karl Mannheim referred to as the "sociology of knowledge," which seeks "to comprehend thought in the concrete setting of an historical- social situation out of which individually differentiated throughway only very gradually emerges. Thus...men in certain groups...have developed a particular style of though in an endless series of responses to certain typical situations characterizing their common position. (Ideology and Utopia: An Introduction to the Sociology of Knowledge, London: Routledge and Kegan Paul Ltd, 1966, p. 3.)

33. Section 1746 and Section 1205, House of Representatives, National Defense Authorization Act for Fiscal Year 1991 (101st Congress, 2d Sess, Report No. 101-923), pp. 176, 181.

34. House of Representatives, Report of the Panel on Military Education of the One Hundredth Congress of the Committee on Armed Services, 101st Congress, 1st Sess, Committee Print No. 4, April 21 1989, p. 19.

35. Ibid., p. 21.

36. See Martin van Creveld, The Training of Officers: From Military Professionalism to Irrelevance (New York: The Free Press, 1990) for an excellent discussion of professional education.

37. Military Education Policy Document, p. II-1.

Expert Risk Assessment for Acquisition

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ABSTRACT

Acquisition involves big risks, particularly with changes in recent world affairs and shrinking budgets. Risk expertise is scarce, and normal job rollover of risk experts could truly hurt a large acquisition effort. Expert systems technology is mature enough to help with routine risk analysis, and to aid the training of new acquisition employees. Several such expert systems have been developed and used in classes at the US Army Logistics Management College at Ft Lee, VA. They include the areas of formal military risk assessment for weapons systems, and estimation of cost uncertainties. These systems allow relatively quick updating for new regulatory requirements or other situations. Students export them for use at their workplaces on personal computers, and report that the systems enhance their acquisition work. One such system will be demonstrated during discussion of the paper.

A DEARTH OF RISK EXPERTS

The number of trained risk analysts available to the DoD community will probably decrease in the medium-term for a number of reasons. As with other specialties, the driving factor is declining budgets. Creating "lean and mean" organizations will involve reductions in force (RIFs), early retirements, hiring freezes and decreased training dollars. Such organizations are likely to have fewer well-trained risk analysts in them. The remaining risk experts are also likely to have a lower level of experience because the more senior analysts will have taken early retirement.

Training can help in this era of uncertainty, but it must be the right kind, and at the right time. Realistic risk asessment requires accurate workshop situations, or on-the-job mentors that can "look over the shoulder" of the trainee and give advice. A more generic problem is the retention and application of training in the field. Techniques learned in the classroom may not be applied until much later on the job. The "forgetting curve" sets in, and the long-term value of expensive training may shrink. As risk assessment techniques become more complex, or policy changes, the transition from classroom setting to field applications may become tenuous. Risk analysis in the field is often more complex than even the more complex case studies used in the classroom.

Expert systems technology is mature enough to fill the need for such job aids in fairly routine situations, and has been implemented as part of advanced Risk and Cost training at the US Army Logistics Management College (ALMC) at Ft Lee, VA.

FIELDED EXPERT SYSTEMS

Expert systems technology involves capturing the knowledge of senior personnel, and making it generally available in an accessible form. Such expert systems are generally quicker to develop than traditional computer programs through the use of what are called "shell" programs. These shells guide the developer through the routine aspects of structuring the knowledge of an expert and displaying it to a novice user. Several such shells are available for the smaller personal computers (PC's) that are widespread in DoD.

Three inter-related steps should help to fight the problem of dwindling risk analysis resources. First, teach the basic techniques to the new analyst in a classroom or concentrated self-paced setting. Second, teach the use of expert systems for the more complex or more routine techniques. Finally, send the expert systems back to the home command with the student, to use as aids or refreshers whenever those particular techniques are needed. Several existing constraints seem to dictate the shape of expert system use within DoD. First, much of the data processing in DoD appears to be done using IBM-compatible PC's. This is not likely to change in the near future. Thus, the expert systems to help guide the use of such processing would be most convenient if installable on PC's. Second, the general training resource constraint is likely to extend to expert systems training. Somehow, personnel must be able to create expert systems with a minimum of training. User-friendly expert system shells can be a key solution to the training and refresher problem.

Many such shells are available, and most require relatively little training. That is, the cost expert can become the primary computer programmer for his or her expert system. Each system should be focused on a particular problem and will typically require less than a week's time for initial development and debugging. Such systems usually involve a few dozen rules in areas such as choice of appropriate risk analysis tools for a particular situation, or choice of the proper statistical tool for development of cost estimating relationships (CER's). Some vendors of such shells will allow executable versions of their products to be used without cost or limit. The use of such rule systems is relatively straightforward, and help is usually available on-line. Every student trained can then take the expert system home for use as needed on the job.

In short, we have seen the future, and it is not expensive [illegible]-based minicomputers programmed by PhD's in artificial intelligence. It is not even programs written from the ground up for the PC in computer languages such as Prolog or some more traditional language, such as Pascal. Instead, it is a quickly-trained expert or instructor who can rapidly prototype and test an expert system on a PC. Most expert systems currently used by the US government run on PC's, and most were written using expert shells.

APPLICATIONS TO RISK ANALYSIS

The risk and cost analysis courses at the US Army Logistics Management College (ALMC) are a combination of policy and analytic techniques. The policy blocks of instruction convey information on regulations and procedures. Because they consist primarily of rules, policies are relatively easy to convert to expert systems. The analytic blocks comprise a [illegible] of deterministic statistical algorithms for estimating time, cost, and performance as well as the attendant uncertainty or risk of each. Again, such algorithms can be converted to expert systems either as rule systems or as a combination of rules and actual calculations. Not all policies or statistical algorithms should be made into expert systems. Using the Pareto principle, one important area for expert systems benefits is in the area of routine decisions. If the risk expert can be relieved from such routine determinations, that expertise can instead be focused on the truly intricate analytic problems. Thus, expert systems might be developed over a relatively short period of time with the aid of the expert, and then used by relative novices or even non-experts as long as the limitations of such expert system usage are made clear.

For example, a system might be developed for routine analysis of many risk studies that must be reviewed. The system would guide an apprentice analyst through the major questions that an expert would ask, using a help facility to amplify and exemplify technical terminology on demand. If the rules in the system determine that the analysis is indeed safely routine, it may recommend a particular conclusion based on the user's inputs. Alternatively, the system may determine that a human expert is needed to perform the analysis because the novice's responses indicate that the analysis is not truly routine. In this way, the expert's time is routed to the difficult 20% of the work that typically requires 80% of an expert analyst's effort.

Another obvious area for expert systems applications is when unaided risk analysts in the field need to deal infrequently with complex rules that are difficult to interpret. Think of the difficulties of assessing risk versus cost for a comparison of single-source and multi-sourced procurement. For any sizeable program, such analysis involves complex evaluations of much data, as well as checks on the legal requirements of each approach. Without expert advice in such situations, poor decisions are likely. Bayesian statistical analysis is another area that demands precision, whereas specific Bayesian skills may be exercised infrequently.

The two examples discussed below should show some major areas of risk work or training where expert systems seem appropriate.

Example 1: Simple Bayesian Analysis. Complex project analysis may demand the use of incomplete or inconsistent historical data for predicting future project activities that may occur conditionally upon other future events. For example, a risky development may only be undertaken if a feasibility study predicts reasonable success of that development; but the analyst must determine expected project duration taking into account both the risky feasibility study and the risky development itself. And, before either activity is actually performed, estimates of their individual and conditional risks are made available based on past historical data for similar events. However, the simple and conditional probabilities of such future events are not directly related to even the best historical information. A typical solution is through Bayesian statistical analysis, but the relationships of available data to needed probabilities are not always obvious. Nevertheless, the procedure is straightforward enough to codify in an expert system.

XBAYES is such an expert system that is implemented in the Knowledge Pro expert shell for IBM-compatible PC's. A main menu requests the user to choose and input appropriate historical data for the problem, both simple and conditional. The system checks for minimally-acceptable types of data and their consistency, and advises the user of incomplete or inconsistent data. When the user input is complete and consistent with Bayesian analysis requirements, the analysis is performed and the results are displayed. In addition, the user may request details of how the computations were performed. This particular application is thus well suited to both classroom instruction and use as a refresher later at work.

Example 2: Statistical Model Selection. ALMC cost courses teach a number of regression techniques for developing cost-estimating relationships (CERs) to aid in the analysis of risky costs. A great many steps must be carefully followed to properly prepare the database, estimate valid CER models, and select the best overall model. The XCER expert system is designed to help the analyst perform this task in the field after memories of course lectures and exercises may have faded.

This expert system is also implemented for PC's. If a number of questions concerning database preparation are successfully answered, the user advances to questions on model estimation. If not, the user is counseled on the likely problems with the database. If no major database problems are apparent, the user answers questions about the statistical validity of his or her cost model. If the answers indicate validity problems, the user is again counseled on possible actions. Finally, the user is guided through detailed selection of the best overall model for use as a CER.

Expert systems like XCER have the advantages and disadvantages of the curriculum upon which they are based. The algorithm is relatively simple, given the sheer magnitude of possible alternatives. It also assumes the user has previous experience or training with the techniques used, and understands all technical terms used. However, this is more a limitation of the initial development of such an expert system. That is, expanded or updated versions of the system are relatively easy to develop if the basic expert shell has capabilities on a par with Knowledge Pro. Such upgrades contain the danger of turning such an expert system from a lean job aid into an over-blown instructional adjunct.

Other applications under development include selection of appropriate risk tools and inflation indices, and aid in reviewing economic analysis and in performing cost/benefits analysis for automated information systems. Students have learned and used several of these systems, and report positive carryover in their jobs.

PITFALLS

The use of expert systems described here is not without its problems. When budgets are constrained, it is tempting to see such expert systems as a kind of automated instruction. This is a mistake. Creating actual programed instruction using PC's requires more resources, time and training than development of specific expert systems for on-the-job application. XBAYES and XCER, for example, can be used only after the user has been properly trained in Bayesian statistical analysis and CER model selection, respectively.

Informal distribution of expert systems as field aids may be difficult in these days of fast-changing policy and the threat of computer tampering or virus introduction. Regular, recognized procedures for updating and disseminating these expert systems will need to be developed and approved.

Finally, although rapid training in the use of expert system shells is available, some quality control is needed in training the developers and screening their products. Poorly trained people will waste their time in developing ill-conceived or substandard expert systems. Another pitfall to avoid is the possible waste of time and resources that sometimes occurs in developing expert systems that merely replace simple checklists. Such checklists take up little space, use no electricity, and are extremely easy to produce and disseminate. On the other hand, a useful checklist may be the launching point for initially developing an expert system that may grow well beyond those modest beginnings. Because of its novelty--interactive, in color--people may show higher interest in a checklist presented through an expert system than when that same list is merely presented on a pale parchment.

CONCLUSION

The PC expert systems industry has matured enough to help with the training and personnel constraints faced by risk analysis today. Such systems, used appropriately, can offer many long-range benefits at the cost of a few weeks of development time and a few hundred dollars of software investment. These artificial intelligence applications appear extremely promising in the face of possible upcoming early retirements and workforce reductions in risk-analysis activities. When used concurrently with instruction, or later as job aids, these expert systems seem to work well. And their risks seem small.

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PROGRAM MANAGER BEHAVIORS

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ABSTRACT

The DSMC "Program Manager Competency Study" identified sixteen competencies which included six which differentiated outstanding program managers from effective program managers.[1] Many vignettes were not included in the original research reports due to the method of analysis. This paper captures some of the stories and strategies described by the various program managers during their interviews.

INTRODUCTION

Critical behavior interviews were conducted with 56 military and civilian program managers representing all services, and whose programs were in various phases of the acquisition life cycle. The purpose of the study was to identify program manager competencies, and determine if the competencies demonstrated by outstanding program managers were different than those demonstrated by effective program managers. Program manager interviews generated 217 critical situations which provided information on their thoughts as well as their behavior. Discussions involving contracting were the most frequent with 47 situations.

The behaviors described in these situations were analyzed and coded. Then, they were grouped into descriptive categories for use in a validation study with a larger group which included functional managers involved in the acquisition of weapons systems. Responses from these acquisition professionals resulted in a different set of priorities and competencies than those of the program managers. Thus, the analysis confirmed that the program manager competency model was not based on generic management behaviors.

Sixteen competencies encompass the program manager competency model. They are listed in Figure 1.[2] Those with an asterisk (*) indicate the competencies which the analysis indicated were significantly different for the group identified as outstanding program managers when compared to the effective program managers.

Figure 1

Program Manager Competencies

Managing the External Environment

1. Sense of Ownership/Mission*
2. Political Awareness
3. Relationship Development*
4. Strategic Influence
5. Interpersonal Assessment*
6. Assertiveness

Managing the Internal Environment

7. Managerial Orientation
8. Results Orientation
9. Critical Inquiry

Managing for Enhanced Performance

10. Long-Term Perspective
11. Focus on Excellence
12. Innovativeness/Initiative
13. Optimizing
14. Systematic Thinking

Proactivity

15. Action Orientation*
16. Proactive Information Gathering

The outstanding program managers were more likely to use these six more often, and over a broader range of situations. Recent *Program Manager* issues contain additional articles on this study.[3,4,5]

The vignettes which follow have not been grouped as the competencies shown in Figure 1, since many contain behaviors which are reflected by two or more competencies. This is an important point to reiterate. Managerial capability results from the complex relationships formed by knowledge, skill, attitude, ability, and experience.

VISION

Since many programs last several decades, several managers indicated the need for a vision, or long term goals. For example, one said, "It's just dumb not to have a vision." He went on to describe how his long term investment strategy impacted his short term investment strategy. Another was more pragmatic when he said the top goal in his job was to get the equipment to the user when they need it, and to support it once it was there. Yet another manager spends an hour or two briefing new personnel on the program's history, and his vision for the future.

One manager was very direct. He said that he could not wait 14 years because the equipment being procured by his office might be the key factor in the next conflict. He made it his personal challenge to build a system in two years, at one tenth the cost of comparable systems, and which would be accepted by his service. While everyone said it could not be done, he knew that he could adapt a commercial product for use in his service's environment.

One's vision can r t be allowed to fade. A decision was made to eliminate a digital display from the program because of its cost. Several years later, however, the opportunity presented itself for the display to be reconsidered. The program Manager (PM) pounced on the opportunity since the digital display enhanced human performance.

PROCESS FOCUS

Isenberg's study of private sector managers found their thinking to be based on organizational and interpersonal processes. By process, he meant "... the ways managers bring people and groups together to handle problems and take action."[6] A review of the interview transcripts found numerous examples.

One PM identified problems in the matrix support he was receiving. He spoke to all of the O-6s who supervised people assigned to him through the matrix, and asked them to help identify the problems. His incentive for support was simple. If the problems continued, ever ody would be embarrassed.

For another situation, this same manager prebriefed all of the heavy weights and members of their staff so that everybody was aware of a situation which required a formal decision. As a result of the briefings prior to the decision briefing, all participants were fully informed so that the actual decision was *fait accompli*.

Six weeks prior to the Defense Acquisition Board (DAB) for his program, another PM described his efforts to assure that the people who had an interest in his program were comfortable with its status. Three weeks prior to the DAB, he went to the Pentagon to peak everyone's knowledge.

Another program manager resisted pressure to get started. He wanted to make sure that he knew who his stakeholders were before he took action; and once they were identified, he got them all to agree to his plan of action.

For programs with systems which may be of value to other services, program managers know that it is advantageous to keep their sister service informed. One interviewee described how he kept another service informed of what the program office was doing to test the system, and invited their full participation in every step of the process.

To meet schedule, some programs depend on the success of a subcontractor. One manager worked with his prime to lay out milestone charts, and show why it was important to track progress. This resulted in the contractor taking action to develop detailed plans describing how the milestones would be reached and what was needed to assure a critical subcontractor's performance.

Reading technical journals provided a key means for linking up people who could propose technical solutions for the program. In discussions with contractor, government laboratory, or program personnel, one manager would frequently mention the work being done by the journal authors. This resulted in a means to link people at the cutting edge of technology. For the program, such linkages resulted in the contractor seeing a business opportunity which required the use IR&D funding to make a key concept work. A decision was made to work toward a technological breakthrough. As it turned out, the concept proved valid, and the service had a new, highly effective system which was a magnitude better than the system it replaced.

One PM received telephone calls from his contractor's president on Sundays. This provided him with an opportunity to solve program problems outside of the formal loop. Another also recognized the power of the telephone, and had an AUTOVON line installed at home. It helped bridge the three hour time difference, and demonstrated an interest that the previous program manager lacked. (This manager indicated that the phone had a cost -- it impacted on his home life.)

On the other hand, another manager always tried to get ten minutes with his contractor's president so he could say hello, and share his perceptions about how the program appeared to be going. This strategy placed him on a first name basis should a major problem arise.

At a time when the media was down on DOD's ability to manage programs, how did one PM handle a production problem which would cause delivery delays? He was going to come right out and issue a press release. The proud contractor had the solution to the problem and a catch-up plan but did not want to go public with a statement regarding the production delay. Agreement between the two was rapid when the government PM asked the contractor PM to consider how bad they would look if the problem was exposed by the media. How did this situation turn out? By issuing the press release soon after the problem was discovered, both managers were pleased to discover only a few back page articles were written.

To launch a major program, it was essential to see key people in Office of the Secretary of Defense, and his service. This required knowledge of both organizations. By briefing them all, the PM was able to line up the support he needed. A different PM said that he was a firm believer in talking to the users, and all of the people involved in his program (including his staff). A different approach was found in another interview. This PM elevated problems so that more people were aware of his program's activities.

Perhaps the importance of networking can be summed up by quoting from one interview. "Networking is everything. You have to know the people." The program is fostered by saying, "This is really important stuff, and we ought to..."

How did a PM minimize problems which might be caused by a subcontractor who was providing hardware to two programs? The PM sought agreement by all parties that decisions would be made in response to the question, "What is in the government's best interest?"

PROBLEM SOLVING APPROACHES

Many problem solving approaches were noted in the interviews. During briefings or discussions, several managers recognized that the schedule would not be met. They made their increased interest apparent by requesting more frequent briefings, asking more questions to help locate or verify problems, and seeking out alternative courses of action.

Several managers held regular meetings to identify and discuss the top concerns for the program. (For one, it was his "Top Ten" list.) In some cases, face to face meetings have been replaced with long distance meetings using varied means of telecommunications and data transmittal. A new PM generated a list of program problems, and found that it was very effective to ask key personnel (his staff, the user, and the contractor) what they thought the problems were. This enabled him to discuss areas where perceptions differed.

When a user did not respond favorably to a PM's approach, the manager developed a comprehensive side-by-side comparison of various systems, and shared it with the user. With a graphic and verbal basis for understanding the direction the PM wanted to take the program, the user concurred with the PM's recommendation. As a result of this agreement, uniformed personnel are more capable of performing their mission any where, any place, any time, and against everything.

ATTITUDE TOWARD PEOPLE

People are a critical factor in the program manager's world. A program management office is faced with a myriad of complex tasks, trade-offs, procedures, and issues. Recalling his first few weeks on the job, a PM reporting in from an operational assignment said, "... the first thing I had to do was inspire the people that I had, and inspire them to performance that they hadn't done before." When new people were needed, he said that he would not hire or take a person who did not want to be in his program, or believe that his program would contribute to his service's fighting capability. As he put it, "It just pays for the PM to go to any length to get the right people." Put another way by a different PM, "... take the extra time to get the top quality candidate rather than follow the temptation" to take the first name off of the list. "I make it a practice of leaving a position vacant unless I can get the right applicant."

Another manager said that he judges people by their work ethic, track record, and goals, and this enables him to place them so they can be of greatest value to the program. Finally, there was the PM who said that his secret was to pick good people, inculcate them in the program, and then turn them loose.

Weather can play a role in achieving a schedule. To be on the safe side, contractor personnel worked over the winter vacation when others took time off. In recognition, of the scheduled delivery date being met, the government program manager had a roll-out to say thanks and show the government's appreciation. In attendance were the state's governor, lieutenant governor, and several flag officers.

When it comes to awards, one PM has a very strong position. He makes sure that the award is presented before the person leaves his program office. In this was, the recipient can be applauded by the people who he or she worked with. Another PM presented a plaque to his contractor for solving a challenging technical problem well ahead of schedule.

Sometimes the PM is aware of a situation but can do little about it. A person on the PM's staff was in a network which included one of the contractor's employees. He learned that the firm was on the verge of bankruptcy. If this did in fact occur, approximately 1400 depot jobs would be at risk. When the bankruptcy occurred, the PM took action to keep the depot personnel employed until a new vender was in production.

There were also some failures which were described. One manager discovered that one of his project officers was a very optimistic person. He recognized that there were problems only after he discovered that the schedule had slipped and he had completely missed it. Another learned too late (the program was cancelled) the value of briefing the program at higher levels. Without these briefings, there was limited knowledge of the impact on the service if the program was "zeroed out." (The interviewee maintained that this was a critical program to the service.)

Then there was the PM who let a laboratory run the show. In looking back, he recognized that this aspect of the program fell apart because he did not do his homework, and work closer with the laboratory's key people.

EMPOWERING OTHERS

A program manager must depend on other people. The words of one PM are clear, "My people are the stars, not me! You have to have confidence in your technical advisors."

One manager needed a strong personality to represent the program at headquarters and gain a commitment to action. Although the person he had in mind was taking a course, he did not hesitate to call him and ask if he would loose anything by missing a day of class. A no was all the PM needed to empower this person to represent him and the program.

Another manager formed a tiger team and asked them to give him a full week analyzing a problem. At the end of the week, they were to report back what was needed to meet the program's objectives, and their recommendations. Most of the team's recommendations were accepted and the problem was corrected. Other PMs also shared stories on why they selected certain people for tiger teams.

People can be made special. One PM's style was to send a good person to the plant and empower him or her to solve problems as they developed, rather than letting the problem fester until the weekly meeting, or a more formal program review.

Due to the program phase, another manager felt that testing should have the highest priority. He created an integration and test unit, and told them that they were special.

Over a decade ago, a program's maintenance schedule was developed for the user. Based on system performance, the current PM felt that he could attain significant savings if the scheduled comprehensive maintenance could be slipped by two years.

with engineering studies which demonstrated that the schedule could be safely slipped, he began planting seeds in the key decision maker's garden. The end result was that the seeds germinated, and the decision maker had an appetizing idea to present to a cost conscious comptroller. (As harvest approaches, it appears that the savings will be significant.)

Another method to empower others is to make them an expert in your system. As described by one PM, "I built the school. It's the way to get control of the people, and get control in the future." At graduation they must understand the entire system, or they do not get certified. Since we are dealing with ordinance, you have to know what you are doing, or it will kill you or someone you don't intend to kill--both of which are unacceptable outcomes!

How does a PM deal with a member of his team who was passed over for O-5? One PM asked, "Are you ready to go to work because I've got some problems, and I want you to solve them." He went on to say that these were the two toughest problems faced by the program, and that he thought that the person was the right one for the job. If successful, it may be the key to being promoted next year. (The end result was that the O-4 was successful, and got his promotion. The PM did his part by making sure that the performance appraisal had the right endorsements.)

CONTRACTING STRATEGIES

One PM described a bid which appeared to be too high. He went through the work breakdown structure line by line to find specifics which would enable the GS-12 government negotiator to take a strong position. The PM's knowledge of the contractor lead to the capitalization of the entire software development program. Such actions resulted in the bid being reduced by 86 million dollars. This was a 33% reduction from the initial bid. By doing his homework,[7] the PM assured himself that the company could afford the program, and that it was executable at that level of compensation. The end result was that the program was delivered on schedule, and at the negotiated price.

Performance is important to PMs. One PM said that, "I pay a lot of attention to a contractor's manning on a project vs. projected and monthly cost performance reports as an indicator of trends." He also looks at the number of items with TBD (To Be Determined) in the interface documents between his two contractors as a sign of danger. In the situation being described, the level was 30%. He confronted them, and gave them deadlines to resolve who would be responsible.

Another PM found four firms in the competitive range; however, one of the firms was three months delinquent in their production of similar items. His position resulted in a production readiness review being conducted on all four bidders since the acquisition strategy was to make awards to two of the firms. Seeing the potential impact on their business base, the delinquent firm went into overdrive and "got well" fast.

What happens when a contractor fails to perform according to the contract? One PM said that when his contractor misses a scheduled delivery, he goes in and asks to be shown where all of the physical parts are in the pipeline and on the assembly line. These answers, in conjunction with the line of balance, give him a good feel for the severity of the schedule slip. On the other hand, the contractor often gets insights which enables some of the problems to be solved.

After getting support from senior

managers, another PM put his contractor on notice that he would use all of the contractual remedies which were available if the contractor continued his non-performance. He did this with the knowledge that it would make relationships even more difficult.

What leverage does a PM have when the product does not meet specifications? Several PMs described how they withheld payment and would not take delivery. In one case, placing the system in operation was the user's top priority. However, the PM convinced the user to back him up on not paying for a product which did not fully match the requirements or specifications.

Another method to seek contract performance was described by another PM. An operational test resulted in failure due to the software. The PM sat down with the contractor and asked for a detailed explanation of the software logic, and how everything worked. By having to make this presentation to the PM, the contractor was forced to analyze the equipment from a system perspective. At the system level, the contractor was able to recognize how to solve the test deficiencies. In the end, the problems were corrected.

Many PMs have very long work weeks. To assure that industry understood what he was looking for, a PM (the PM with a vision of operational capability in two years at one-tenth the cost) spent evenings and weekends talking to industry. When he wound up with 126 requests for the RFP, he knew he had been successful. However, he was also concerned that he may have generated too much competition. As luck would have it, only eight firms submitted proposals, and all of the bids were within his cost projections.

Sometimes, the PM has to be creative. After surveying firms which might be able to meet his needs, one PM found one firm he thought could be successful, and another firm with the potential to develop his system. His strategy was to get each of the firms to recognize their strengths, and go sole source to both.

The ideal situation is win/win for the service and the contractor. One PM accomplished this by planning to be on contract in the first quarter of the Fiscal Year. In this way, the sale would be on the contractor's books for the calendar year, and his service would not have to hound him about obligating his program's money.

Evaluating proposals is often a time consuming task. In an effort to streamline the process, one manager got his technical people to write the technical section so that contractors could respond to modules. To assure that the potential vendors understood, he made sure that time was built into the RFP process for face to face meetings to clarify the requirements. In this way, the government evaluators would not have to jump all around the proposal, and the bidders would respond to clear requirements.

Finally, there was the PM who exploded when he read a follow-up proposal which stated that the learning curves had been estimated. (The contractor had five years of experience in the system.)

OTHER VIGNETTES

Despite long hours, program management has its lighter side. A critical test was being run in a remote location. The test had to be delayed until the source of voltage fluctuations was found. It turned out that the cause was a bull who had decided to scratch his back on a wire which was supporting the pole of the electric line.

Another PM had President Reagan as a role model. He used the jelly bean briefing technique. After a year of effort, he had to deliver a critical briefing to flag officers. Briefing preparation included putting jelly beans on the table. He figured that if they were eating the candy, they would listen to his presentation instead of challenging every item, or seek to control the decisions the group would make.

A Rolls Royce was part of another manager's strategy to reduce the cost of his system. The government should cost was $30,000, and the most recent contract price was $106,000. At 600 per year, the contractor justified this price on the basis that this was not an economical order quantity. On one visit to the plant, the government PM rented a Rolls Royce (200 are produced each year) and parked it beside the system. He then asked his counterpart to justify the price difference (The Rolls was $100,000 plus tax). Although the contractor continued to justify his own product's price, the point was made. Over time, the cost of the system was driven down over 60% (probably due to the dual source acquisition strategy, and the very realistic possibility of a qualified off-shore contractor becoming a third player.)

Believe it or not, one PM started out his career as a medic. A senior officer had an injury which required several stitches. As would be expected, he went to the hospital to have them removed. His doctor could not be found, and no one else at the facility would take action. So he came back to his boss and called upon the PM's past expertise in removing the stitches.

For one research and development effort, the PM decided that determining if the concept would work was his top priority. In the process, he found that he could save money by using non-standard parts. For the R & D phase, he saw no need to use nuclear qualified parts, or extensive periods for burn-in. After all, each of these concerns could be addressed in the next phase.

For one PM, foreign military sales resulted in the development of a more capable system for the United States. The PM suggested system upgrades which the foreign country thought were super. They gave the go-ahead and paid the development costs. As a result, the PM saved the American taxpayer 70 million dollars.

PMs have to adapt to change. One was frustrated that the Pentagon had given him one hour to propose how to revamp his program with a 70% funding cut. The original plan had taken six months to develop. Yet a different manager said that when taking over the program his top priority was office automation which would enable him to submit a workable program budget whenever someone in Washington requested "what if" information.

Another was caught short when he was told that his program would cease. Instead of going through a normal phase out, he sought to find other uses for the parts of his system. For example, one part of his system appeared to be a proven substitute for another service's program which was going nowhere in its R & D phase. In this way, personnel assigned to his program were highly motivated.

Over specification can make the headlines. One PM recognized that his system did not require an operational capability of 60° below zero. Without this requirement, he would reduce the program's cost by millions. His back-up was an electric blanket. If the equipment needed to be operated at the South Pole, he have a procedure which required the equipment to be wrapped in an electric blanket.

Finally, there is the manager who did not want to do a Paul Revere act, and ride to Washington every time something went wrong. As a manager, he had confidence in his ability to give himself some time to solve the problem.

CONCLUSION

Each manager brings diverse knowledge and experience to the job, and this was reflected in the incidents they chose to share. Many diverse situations have been described in this paper in an effort to share some of the strategies and stories which were told to the "Program Manager Competency Study" interviewers. Their dedication to duty stood out as an overall quality, and philosophically speaking, the program manager is the person who should be worrying about the things no one else is worrying about.

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ACHIEVING EXCELLENCE IN MANAGEMENT OF DEFENSE SYSTEMS

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ABSTRACT

David Packard, Chairman of the President's Blue Ribbon Commission on Defense Management, and the father of DOD Directive 5000.1 which governs how DOD acquires defense systems today, made some profound observations in his Foreword to the Commission's Report to President Reagan. They include the observation that the large size and complexity of the national defense enterprise "requires that we cultivate resilient *centers of management excellence* dedicated to advancing DoD's goals and objectives." He also stated what he believed was required for excellence to emerge, and what conditions were necessary for excellence to flourish.

We consider his observations and statements first, and propose what management knowledge and information (K&I) is required for excellence to emerge, and the conditions necessary for excellence to flourish, i.e., to maintain excellence in the centers.

Next, we propose that the domain of integrated Defense Systems Management (DSM) should extend beyond DSAM (Defense Systems Acquisition Management), to integrated management of defense systems over their entire life cycles.

Then, we outline concepts that will enable evolutionary development of K&I Structure and Information Systems (K&I-SIS), which in turn, will enable timely, selective, on-demand access to relevant DSM K&I for DSM tasks. This will provide the DSM K&I that are required for cultivation, emergence and maintenance of DSM centers of management excellence.

Finally, we propose that DOD begin immediately to develop a DOD DSAM-SIS for early use in defense systems acquisition, and as the first step in evolutionary development of an Integrated DSM-SIS (IDSM-SIS) that can support the entire DSM community.

INTRODUCTION

Background. President Reagan established the President's Blue Ribbon Commission on Defense Management in July 1985. The President charged that the final report on the issues the Commission considered, would "recommend how to improve the effectiveness and stability of resources allocation for defense, including the legislative process."[1]

Fulfilling the President's charge concerning the defense resources allocation process, the Commission reported its full findings and recommendations in its final report, *In Search of Excellence*,[2] on June 30, 1986. Our paper is an outline of interdependent concepts concerning defense systems management, which we are developing in response to observations by the Commission's chairman, David Packard, in his Foreword to the report.

Responding to the President's charge, the Commission focused their recommendations on establishing strong sound centralized policies. The Reagan and Bush Administrations and the Congress have implemented many of the Commission's recommendations, particularly those for needed changes in organizational structure and relationships. However, achieving excellence in management of defense systems will require more than implementing the Commission's recommendations.

Chairman Packard, father of the process DOD uses today to acquire defense systems,[3] recognized this in his Foreword. He specified, in the following excerpts from his Foreword (Figure 1) the key requirements for excellence in executing centralized management policies through discrete structures.

Scope. Chairman Packard believed that these requirements for excellence in management must be met to realize the benefits expected from implementing the Commission's recommendations.

One of the key requirements is management knowledge. Packard cites or implies the requirement for knowledge several times. We emphasize each cite by adding underlines in the excerpts. Our analysis tells us timely access to relevant knowledge for management tasks at hand, is key to excellence in defense system management processes, not only in the defense systems acquisition management process, but also in two other defense systems management processes during a system's life cycle.

Furthermore, excellence in these management processes should assure that the quality of each defense system[5] (e.g., operational suitability and effectiveness[6] of the system at an affordable cost) is

> The Commission's recommendations are intended to help establish strong centralized policies that are both sound in themselves and rigidly adhered to throughout the Department of Defense (DoD). In any large organization, policies must be executed through discrete structures. In the large complex enterprise of national defense, this requires that we cultivate resilient *centers of management excellence* dedicated to advancing DoD's goals and objectives.
>
> Excellence can flourish, I believe, only where individuals identify with a team, take personal pride in their work, concentrate their unique efforts, develop specialized know-how, and above all constantly explore new and better ways to get their job done.
>
> Excellence in defense management will not and cannot emerge by legislation or directive. Excellence requires the opposite--responsibility and authority placed firmly in the hands of those at the working level, who have knowledge and enthusiasm for the tasks at hand.[4] (Underlines added for emphasis)

Figure 1. Excerpts from Chairman Packard's Foreword

maintained over the <u>entire life cycle</u> of each system.

The issue is how to begin assuring that defense system quality, as defined above, is a main objective of each separate process. Our answer is to integrate the separate processes into one Defense Systems Management (DSM) process to manage each defense system over its entire life cycle. We believe that the DSM process is a new concept, the result of "systems thinking" about defense systems. The DSM concept is explained under the heading, Domain of DSM.

In our concept, the DSM process includes the following subprocesses. These subprocesses sequentially cover the entire time line of each defense system's life cycle:

— DSAM (Defense Systems Acquisition Management) through production and deployment of each defense system.

— OESM (Operational Employment Support Management) of each fielded defense system throughout its operational employment.

— DSDM (Defense Systems Disposition Management) of each system's disposition in an environmentally acceptable manner when the system no longer meets the quality criteria.

Our paper focuses on DSM and other concepts, which integrated together, should help us understand what is required to assure excellence through timely, selective, on-demand access to relevant knowledge (and information, the most recent increment of the knowledge) for DSM tasks at hand.

Considering insights gained from Chairman Packard's Foreword, and observing that the Commission's report focused on the DSAM (first) phase of a defense system's entire life cycle, this paper focuses on four interrelated DSM issues:

1. What is necessary for productive cultivation and maintenance of "*centers of management excellence*?"
2. What should be the domain of the Defense Systems Management (DSM) process?
3. What is necessary to integrate the three separate DSM processes into an Integrated DSM (IDSM) process over each defense system's life cycle?
4. What should DOD do immediately, as a first step in the evolutionary development of a DOD Integrated DSM Structure and Information System (DOD IDSM-SIS)?

CENTERS OF EXCELLENCE

Chairman David Packard recognized that implementing the Commission's recommendations, which intended to help establish strong sound centralized DOD policies, would not be sufficient. DOD is large and complex. This necessitates policy execution through discrete structures, a process which cannot necessarily assure rigid adherence to centralized policy.

The issue is: How to assure timely, coordinated, effective execution of centralized policies through necessarily discrete structures?

Packard experienced in defense management, industry, and as Deputy Secretary of Defense for three years, the problems of establishing sound centralized DOD defense management policies. Equally important, he knew the problems of achieving rigid adherence to the centralized policies in their execution through discrete structures.

Based on his broad experience and knowledge, Chairman Packard specified a solution for problems that stem from decentralized execution of centralized policies. His solution: Effective execution of centralized national defense policies through necessarily discrete structures requires cultivation of resilient *centers of management excellence* that are dedicated to achieving the defense policy goals and objectives."

Given this solution, consider (1) that ever-changing political, economic and international environments may alter the centralized DOD policies, and (2) that these centers must coordinate their respective discrete efforts, in order to contribute effectively toward achieving the current overall national defense goals and objectives which involve defense systems. The issue becomes more complex:

— What is required to cultivate and maintain the centers of management excellence?

Our analysis indicates that four kinds of knowledge and information (K&I) are required to cultivate and maintain these DSM centers of management excellence. We consider the four in the order stated.

The first two are (1) knowledge of the requirements for excellence to emerge, and (2) conditions that must be maintained for excellence to flourish after it emerges.

The third is knowledge of the domain of Defense Systems Management (DSM). This knowledge is required:

— To assure that these centers of management excellence are dedicated to advancing the quality objective of DSM: achieve, maintain and improve operational suitability of the system, and maintain operational effectiveness of the system (e.g., through continued man-machine integration), all at an affordable cost, in changing environments, throughout the entire life cycle of each system, and

— To identify the DSM subprocesses in which centers of management excellence should be cultivated.

The fourth is knowledge of the kinds of K&I aids and systems that are required to support the cultivation, emergence and maintenance of centers of management excellence.

Requirements. Chairman Packard specifies three requirements which must be met for excellence to emerge:

— Responsibility and authority placed firmly in the hands of those at the working level (i.e., those directly responsible for doing the job, whether a high-level task such as establishing major policies, or lower-level tasks of executing policies.)

— Enthusiasm for the tasks at hand.

— Knowledge (including the most recent additions, i.e., current information) for the tasks at hand.

Chairman Packard also stated his experience-based belief that excellence cannot emerge by legislation or directive.

The responsibility and authority requirement can be met through formal organization and stated management policy. The second requirement, enthusiasm, can be met by selecting professionals who have enthusiasm, to staff the centers.

The problem of how to meet the relevant knowledge and current information requirement for excellence is more complex. We will address this problem, and also the question of where centers of management excellence should be cultivated, after identifying the conditions required for excellence to flourish.

Conditions. Chairman Packard identified five key conditions required for excellence to flourish (second excerpt).

Three of the conditions--identifying with a team, taking personal pride in their work, and concentrating their unique efforts--are determined by the characteristics and attitudes of the individuals assigned to the centers. These conditions can be met by selecting individuals to staff the centers who already have the required characteristics.

The other two--developing (and maintaining) specialized know-how, and constantly exploring new and better ways to get their job done--require that each center be provided aids for timely, selective, on-demand, access by each member to relevant sources for any needed specialized know-how. In addition, the aids must support individual exploration of external DSM K&I sources for new (to the individual) and better ways to get their job done.

We are now ready to begin considering what other knowledge is required to assure excellence in management of defense systems.

DOMAIN OF DSM

The Commission's report focused on the most acute defense management problems of the mid-1980s, with emphasis on improving defense management organizational relationships. In addition, it focused on problems in program management of weapon (defense) system acquisitions, during the DSAM phase. The Commission showed little concern about program management of defense systems during the rest of a system's life cycle.

Our analysis now indicates that extending the domain of defense systems management throughout the entire life cycle of each defense system would give significant payoff: in enhanced operational suitability and effectiveness of the defense system, in dollars saved, and in better defense systems management education.

DSM Concept. Based on our analysis and research, we propose a new systems management concept, Defense Systems Management (DSM). It encompasses much more than the life cycle cost model, and it depends greatly on emerging information management technologies. This is a concept for increasingly integrated management of all systems throughout each defense system's life cycle.

From a "systems thinking" viewpoint, the DSM process has an input, many transformation processes, and an output. The input to the process is a need for the defense system. The <u>output</u> of the DSM process is not the defense system, rather its quality demonstrated by the adequate <u>operational suitability</u> and <u>effectiveness</u> of the system (as an instrument for achieving military objectives) at an affordable cost, in changing environments, throughout the system's entire life cycle. Then when the system's operational suitability and effectiveness are no longer adequate to meet an existing need at affordable cost, the life cycle ends with disposal that is militarily, economically and environmentally acceptable.

When implemented, the DSM process will include the three subprocesses--DSAM, OESM, and DSDM--named in the introduction. Its main objective is to achieve and maintain system quality as defined above. Focusing attention on system quality based on a system life cycle view merits serious attention in any efforts to improve defense systems management.

Likewise, professional education institutions should consider developing DSM curricula from the viewpoint of a defense system's life cycle. For example, DSAM, OESM and DSDM subprocess courses, which cover the unique aspects of each DSM subprocess, should be "subsets" of an overall DSM-core DSM educational program.

Determining the appropriate domain of the whole DSM process is important to its implementation. It bounds the areas and organizations which require cultivation and maintenance of centers of defense systems management excellence. In addition, it will be the domain for determining specific subjects of DSM throughout every system's life cycle, including DSM education, which should be the concern of the whole DSM community (i.e., professionals involved in the OESM and DSDM processes, as well as the DSAM process).

Our examples and recommendations in this paper, however, will focus mainly on the DSAM phase, because our research indicates the DSAM phase is the place to begin evolutionary development of the K&I systems that we envision. It also tells us that these K&I systems are required to interconnect centers of management, and enable them to become the centers of management excellence, which Chairman Packard said are required.

Boundaries of DSM. The boundaries of the Defense Systems Management (DSM) Process span both a hierarchy and a time line (life cycle):

a. DSM spans a great managerial hierarchy, which ranges from establishing all centralized national defense policies that involve defense systems, down through numerous organizational hierarchies to the management level(s) where these policies are finally executed.

b. The boundaries also span the DSM time line (illustrated in Figure 2) which:

— Begins with determination of the need for a system, and continues throughout the DSAM process (management of each system's acquisition through its production and deployment; by DSAM professionals).

— Continues throughout the OESM process (management of each fielded system throughout its operational employment). The OESM professionals:

- Complete test and evaluation, begun during the DSAM process, with Operational Test and Evaluation (OT&E); managed by OT&E professionals.

- Continue the Man-Machine Integration (M-MI) program, begun early during the DSAM process, to maintain and improve the overall system's operational suitability and effectiveness in a changing world environment; managed by Forces, Manpower, Personnel, Training and Safety (FMPTS) professionals.
- Implement Logistics and Infrastructure Support (L&IS) planning completed during the DSAM process, and provide logistics and infrastructure support for the fielded system; managed by Integrated Logistics Support (ILS) and Infrastructure Support (IS) professionals.

— Ends with the DSDM process (management of its final disposition in an environmentally acceptable manner; by System Disposal (SD) professionals) after the system is no longer as suitable as other alternatives to meet a defense need.

We should note that definitions of boundaries between processes are based on the "culture" and objectives of the professionals working in each process (e.g., DSAM, OESM, and DSDM). Implicit in any definition of boundaries, is the assumption that all professionals working in the particular process have a common working language (i.e., common concepts, with each concept represented by the same term). Disconnects and misunderstandings in communications, and discontinuities in the management process, result when the assumption proves false.

The Commission focused on the DSAM process. Despite some progress in recognizing life cycle costs of defense systems, integrated program management in the DSM process still seems largely limited to the DSAM subprocess. Different groups of professionals, from different "cultures," manage each system during the different DSAM, OESM and DSDM phases of its life cycle. Often, there have been substantial functional management process discontinuities and communications disconnects (e.g., between the DSAM process and what we have defined as the OESM process), even though Test & Evaluation, Man-Machine Integration, and Logistics & Infrastructure Support, should be continuous functions across the processes. These discontinuities have been a serious source of deficient system performance and wastefully high life cycle costs in too many defense systems.

One can conclude from these communications disconnects and management process discontinuities, that DSM professionals working in the DSAM and the OESM phases do not share a common working language (common concepts and terms for similar DSM phenomena). Without a common working language, integrated management is not possible.

<u>Integrated DSM Processes</u>. Our analysis indicates that a more integrated DSM view of each defense system's life cycle (1) should, during the DSAM phase, improve the early identification, correction and elimination of many operational suitability problems; and (2) should enable better preparation to cope, in the OESM phase, with identified problems which could not be eliminated. This approach appears to have already started in selected cases. For example, better man-machine

integration during the DSAM process to achieve greater operational effectiveness of the overall system.[7]

Broader application of this integrated DSM view would foster continuing into the OESM phase, critical DSM activities which begin during the DSAM phase. The dashed lines in Figure 2 identify examples: Test & Evaluation, Man-Machine Integration, and Logistics & Infrastructure Support.[8]

The top part of Figure 2 portrays our new concept of a Defense Systems Management (DSM) view of a defense system's life cycle, with:

— Three consecutive phases: DSAM, OESM, and DSDM. The concepts these acronyms represent are described above. Other acronyms could be used.

— Concepts of several categories of DSM Knowledge and Information (K&I) Systems that we believe are required to support centers of management excellence in each phase. There are more. Some already exist, others should be developed, and all need to be better integrated.

— Some of the kinds of knowledge and information that particular DSM K&I Systems could, or already are providing in each DSM phase.

The DOD should act to develop a DSM K&I Structure & Information System (described later) for each phase (DSAM-SIS, OESM-SIS, DSDM-SIS), based on this DSM view of each defense system's life cycle. This would effectively extend the domain of defense systems management, from comprising only the DSAM process, to encompassing all three phases of the DSM process that are represented in the top part of Figure 2.

The lower part of Figure 2 portrays the Integrated DSM (IDSM) view of a defense system's life cycle. Enabling concepts for implementing this IDSM view are outlined next. Basically, implementing this integrated IDSM view involves evolutionary integration of the standardized common languages for each DSM phase, into one standardized common IDSM language. This IDSM language will interconnect all centers of management excellence and all DSM K&I systems. DOD implementation of this integrated IDSM view would enable:

a. Timely knowledge and information <u>feedback</u> from OESM to DSAM, for correcting during the system's acquisition, many of the surprise defense system problems that are often encountered later during operational employment of fielded systems. Numerous defense system examples document that correcting or coping with surprise system problems, when not discovered until operational employment in the OESM phase, has been exceedingly costly in time and dollars, and in operational suitability and effectiveness.

b. Timely knowledge and information "<u>feedforward</u>" from DSAM to OESM:

— To support effective continuation of activities during operational employment, that intend to maintain and improve each system's operational suitability and effectiveness in changing environments.

— To anticipate unique support needs, and aid preparation for essential logistics and infrastructure support activities throughout the defense system's operational employment.

interconnection to assure timely access to relevant IDSM K&I.

DEFENSE SYSTEMS MANAGEMENT (DSM) over the Life Cycle of Each Defense System		
Acquisition DSAM Phase	Operational Employment Support OESM Phase	Disposition DSDM Phase
DSM Knowledge & Information (K&I) Systems		
DSAM K&I DT&E K&I - M-MIM K&I- L&ISM K&I-	OESM K&I - OT&E K&I - - - - - - - - - - - - - M-MIM K&I - - - - - - L&ISM (ILSM & ISM) K&I-	DSDM K&I - - ILSM K&I
Kinds of Knowledge & Information Provided by DSM K&I Systems		
Milestones 0-IV Phases I-IV FMPT&S Prog L&IS Planng	Operational Test & Evaluation Man-Machine Integration Intg Log Spt & Infrastructure Spt	Foreign Military Assistance Recycle/Salvage Environmental
INTEGRATED DEFENSE SYSTEMS MANAGEMENT (IDSM) over the Life Cycle of each Defense System, achieved by interconnecting with a Standardized Common IDSM Language, all Centers of Management Excellence & all DSM K&I Systems		

Figure 2. DSM (Defense Systems Management) & IDSM

ENABLING CONCEPTS

We are ready now to consider extending DSM beyond the three-phase DSM concept, portrayed in the top part of Figure 2, to the Integrated DSM (IDSM) concept implied in the lowest part. Understanding this extension will require an awareness of the following enabling IDSM concepts:

— Integrated Defense Systems Management (IDSM) concept.

— Defense Suprasystems concept for coping conceptually with organizational complexity.

— General specifications for DSM K&I systems and for their interconnection to assure timely access to relevant IDSM K&I.

— Structure and Information Systems (SIS) concepts, and the crucial role of SIS in cultivation, emergence and maintenance of DSM and IDSM centers of management excellence.

Due to time and space constraints, however, what follows is more an outline of these concepts. Some are tentative. All are from a longer draft paper that we are still researching and writing.

IDSM Concept. Presently, defense systems are not managed on an integrated basis throughout their life cycles.

One critical result is communications disconnects and management process discontinuities between separate DSAM, OESM and DSDM processes.

These disconnects and discontinuities are mainly due to the lack of a standardized common IDSM working language (explained above). Both the medical and legal professions have overcome communications disconnects and process discontinuities within their respective professions by developing their own professional jargon, specialized professional vocabulary or idioms with consistent definitions throughout each profession. This enables medical and legal professionals to communicate unambiguously with others in their professional activities, and to develop huge medical and legal databases which all can access directly as their K&I needs arise. Why not DSM professionals?

The Integrated Defense Systems Management (IDSM) concept is based on an "informational" integration of the K&I that are required in each DSM phase. Integration will be achieved by applying the other enabling K&I concepts to develop a standardized integrated IDSM professional language. Then, all professionals in DSM centers of management excellence can use the common language, not only to access K&I and to coordinate discrete efforts with other professionals working in their respective DSM phases, but also to do this across boundaries between the DSM phases.

No other practical alternative is available. Consider problems encountered with past and current organizational approaches for improving program management integration in only the DSAM process. Examples include the program-management organizational structure problems faced by the Packard Commission, and by the Administration and the Congress in their efforts to implement the Commission's recommendations to establish the USDA, SAE and PEO positions.[9] Such organizational structure changes may correct some authority-responsibility deficiencies, but they do not solve the problem of timely K&I access. Nor do structure changes correct management-turf problems, at all organizational levels, which also impede timely K&I access.

Integrated defense systems management (IDSM) throughout the life cycle of each defense system cannot, in the complex bureaucracy concerned with national defense, be achieved organizationally. But, combined with the centers of management excellence concept, and using new K&I concepts and "informational" integration, IDSM can be achieved <u>operationally</u>! Our research[10] supports the position that program management integration can be effectively maintained over a system's life cycle through integration of DSM K&I (i.e., through IDSM K&I).

IDSM can be achieved by providing each center of management excellence (in DSAM, in OESM, and in DSDM), timely access to the IDSM knowledge and information (K&I) that it requires for four main purposes:

— To continually know and have a common understanding of the goals and objectives of DOD's centralized policies.

— To clearly coordinate each center's respective efforts in its area of responsibilities, toward coordinated execution of the commonly understood centralized defense systems management policies, in order for all to contribute productively to achieving DOD's goals and objectives.

— To develop additional needed specialized know-how and find new and better ways for getting their job done.

— To perform with excellence any management tasks at hand, whether they be establishing centralized DOD policy, or lowest level coordinated execution of the policies.

The only practical solution is to assure that every DSM center of management excellence has timely access to IDSM knowledge and information (K&I) that it requires for these four above purposes.

Defense Suprasystems. The purpose of the concept, Defense Suprasystems, is to help cope with organizational complexity in the huge national defense enterprise in government and industry. Application of these concepts will provide descending hierarchies of national defense and defense system management objectives and goals for the five defense suprasystems listed below. These objectives and goals are needed to guide discrete execution of centralized DOD policies, in centers of management excellence at all levels in each suprasystem.

We expanded a well known systems concept for single organizations[11] into a concept of organizational systems, which we named *organizational suprasystems*. This concept views any large group of highly interrelated organizations with mutual goals and objectives, as an integrated open *suprasystem* composed of three subsystems: goals, objectives and values of the suprasystem; a structural subsystem concerned with patterns of authority, and particularly with channels of communication and information flow and access; and a managerial subsystem that establishes structural interfaces with other organizational systems and relates the suprasystem to its environments.

We identified five defense organizational suprasystems:

— Systems Acquisition organizational systems.

— Man-Machine Integration Management (M-MIM) organizational systems, involving forces, manpower, personnel, training and safety.

— Logistics & Infrastructure Support Management (L&ISM) organizational systems.

— Defense Systems Industrial Base organizational systems.

— Operational Military Forces organizational systems.

These are the principal organizational suprasystems involved in the whole DSM process defined in the introduction. Centers of management excellence should be cultivated throughout the first four, and in the last, at critical points of contact for information exchange with the other four suprasystems.

DSM K&I Systems. Thus far, we have looked at several factors that affect the kind of knowledge and information (K&I) aids that must be developed and maintained to support the cultivation, emergence and maintenance of centers of management excellence.

A review of these factors indicates that K&I aids to professionals in the centers of management excellence, must be able to provide on-demand, timely, selective access to

K&I that is relevant for any of the four purposes listed under the IDSM concept above.

And where DSM tasks can be forecast or scheduled, the K&I aids should be able to automatically deliver only relevant K&I to meet the task needs, and avoid inundating the center with useless data.

Considering these requirements, the critical issue is:

— Where and through what means can K&I be collected, organized, indexed and stored for retrieval, either through timely on-demand access, or for automatic delivery?

This obviously requires continued evolutionary development of K&I systems which will have the capabilities of the K&I aids discussed above, as well as other capabilities which we outline below.

Five categories of DSM K&I Systems are identified in Figure 2. There are more, but these systems are enough to illustrate the IDSM K&I Systems concept, and how integrated program management of defense systems over the entire life cycle of each defense system might be achieved. The five illustrative categories of DSM K&I Systems are:

— DSAM (Defense Systems Acquisition Management) K&I Systems, numbering hundreds.

— OT&E* (Operational Test & Evaluation) K&I Systems.

— M-MIM* (Man-Machine Integration Management) K&I Systems.

— L&ISM* (Logistics and Infrastructure Support Management) Systems.

— DSDM (Defense Systems Disposition Management) K&I Systems.

Each category represents from several to possibly hundreds of K&I systems needed to support, either (a) management of specific defense system programs, or (b) integrated management programs, applicable to many defense systems. We believe these K&I systems, particularly those supporting integrated management programs, should cross phase boundaries (indicated by dashed lines in Figure 2). They should operate in two or all DSM phases. Three of the latter (denoted by asterisks) are documented in the most recent draft of an extensive revision of DSAM policies and procedures.[12]

Structure & Information Systems. Many of the K&I systems are designed to support one DSM phase. However, the primary objective of professionals in all DSM phases should be to achieve or maintain the quality of defense systems as defined in the introduction. So, K&I from most of these numerous K&I systems should be useful to DSM professionals working in any DSM phase, if they only knew the existence of relevant K&I, and better yet, how to access it. Considering this, the critical issue becomes,

— What other kind of system is required which professionals in a DSM center of management excellence can access:

- To find all standardized macro-level taxonomical terms, which managers of organized collections of K&I (e.g., special databases, libraries and repositories, CD-ROM discs, analysis centers) have used to classify, organize and index the major facets of DSAM K&I (perhaps 2 -30) contained in each organized K&I collection in a K&I system, and

- To identify which, if any, of these collections in K&I systems, most likely contain specific items of K&I that are relevant for a task at hand?

The solution is K&I Structure & Information Systems (K&I-SIS), which comprise a Structure System and an Information System. DSM K&I-SIS should be developed for each DSM phase (DSAM-SIS, OESM-SIS, and DSDM-SIS) for use by centers of management excellence operating in the phase. An integrated IDSM-SIS would enable all centers of management throughout the entire DSM community to access K&I that is relevant to each center's tasks at hand.

Structure Systems. In general, the Structure System is a DSM Taxonomy-Glossary, comprised of a taxonomy and a complementary authenticated glossary. The taxonomy consists of controlled DSM terms which are used and understood by DSM professionals working in a particular DSM phase. The complementary authenticated glossary defines the concept represented by each term in the taxonomy.

To illustrate, we use a DSAM-SIS which could be developed for the DSAM phase as an example. The Structure System of the DSAM-SIS is a DSAM Taxonomy-Glossary of the body of DSAM knowledge and information (K&I). The Taxonomy will resemble a thesaurus, but of major DSAM macro-level taxonomical terms and concepts. DSM professionals working in the DSAM phase, will use it to group and classify, all organized collections of program and functional management K&I, needed to achieve the goals and objectives of the acquisition phase.

In one sense, a DOD DSAM Taxonomy-Glossary would document, at a macro level, the standardized common DSAM working language (jargon) for clear communications in management of defense systems acquisition in the DSAM phase. If used throughout DOD to classify, organize, and index the major facets of collections of DSAM K&I, then every DSAM center of management excellence could quickly identify the general content of all collections of DSAM K&I. The same concepts apply for an OESM and DSDM, and more so, for an IDSM Taxonomy-Glossary.

Information Systems. Continuing with the DSAM phase example, the other part of a practical DSAM Structure & Information System (DSAM-SIS) is a special Information System. It is required because the problems of assuring timely access to relevant K&I in the vast body of existing available DSM K&I are so complex--the needle in a haystack problem, which part to search first.

To help reduce the complexity and also provide an early workable solution, we suggest dividing the K&I access process into two stages. For the first stage, we added a special Information System, as an integral part of the macro-level SIS. It can identify the sources of collected DSAM K&I which are available in each major DSAM area of the Structure System (e.g., indexed by the DSAM Taxonomy term representing the DSAM area). In addition, it can provide data on how to contact each source of an organized collection to get direct access to the collection's K&I content. Thus, this DSAM-SIS provides the first part of the practical two-stage solution to the timely, selective, on-demand access problem. It helps determine where in the haystack to start a search.

Once the Information System has been used to identify sources of best collections of relevant K&I for a center of management excellence, each DSM professional can interact directly with each chosen source, and thus, get timely, selective, on-demand access to any relevant K&I, contained in the source collection, that is applicable to a task at hand.

DOD DSAM-SIS

The need is urgent. The DOD should begin immediately to develop a macro-level DOD DSAM-SIS.

The DSAM Structure System for this DSAM-SIS will be similar to the DSAM Structure System described in the example above. It will provide a macro-level, standardized common DSAM working language:

— For use throughout DOD to classify and index collections of DSAM K&I, so every DSAM center of management excellence can use the DSAM Information System to quickly identify the general content and specific location of all collections of potentially useful DSAM K&I.

— For clear macro-level DSAM communications among DSAM centers of management excellence throughout DSAM communities (e.g., in the five categories of defense organizational suprasystems in government, industry, business and academia) in the management of defense systems acquisition in the DSAM phase.

— As a first step in evolutionary development of an integrated IDSM-SIS, which could be used at the macro level for both purposes above, by all DSM centers of management excellence, in all five suprasystems, in management of defense systems during all DSM phases throughout the entire life cycles of all defense systems.

The DSAM Information System for the DSAM-SIS should:

— Identify available sources of potentially useful organized collections of DSAM K&I, and the major facets of DSAM K&I (perhaps 2-30) contained and accessible in each K&I collection.

— Tell how any DSM professional can contact each source, and the modes available for interacting with the manager(s) of each K&I collection, or more directly with the contents of the K&I collection itself (e.g., personal visit, telephone or fax interaction with managers, or direct access to the contents of K&I collections through on-line access systems, and in the future, through CALS[13]).

Thus, the DOD DSAM-SIS will provide (1) a standardized macro-level structure of the body of program and functional management knowledge and information (K&I) needed to manage acquisition of defense systems during the DSAM phase, and (2) identification of relevant sources for timely, selective, on-demand access to more detailed items of relevant K&I needed for tasks at hand.

The DOD DSAM-SIS will serve two purposes for its DSAM phase. Its standardized common DSAM language (jargon) will interconnect, at a macro level, all DSAM centers of management excellence. This language can also be used

DELEGATION OF PROCUREMENT AUTHORITY IN THE DECENTRALIZED ORGANIZATION: REVISITED

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ABSTRACT

The paper, "Contract Complexity and a Decentralized Organization", was published in the *Proceedings of the 1985 Federal Acquisition Symposium*. That paper described a Forest Service (USDA) proposal for a new way to delegate procurement authority in its decentralized organization. The proposal involved training of people, appropriate position descriptions, and the use of work complexity rather than simply using dollar amounts when delegating procurement authority. In essence, it combined dollar values with complexity determination to accomplish the assignment of work to purchasing agents and contract specialists in isolated locations with relatively small workloads as well as in larger procurement offices. The paper suggested that this approach would be useful to any organization that was decentralized and wished to accomplish its procurement at the work site rather than at central locations.

The proposal has now been fully implemented and is working well. This paper describes that implementation and the change and compromise that accompanied moving the proposal into an operational environment. Since the original implementation, the Forest Service has established clear classification standards for both the non-supervisory GS-11 and GS-12 contract specialists and has also developed standard position descriptions for non-supervisory GS-8 and GS-9 purchasing agents. This effort involved not only clarifying what work should be accomplished at different levels within series but also what the procurement complexity dividing line was between the 1105 and the 1102 series. This was not an easy issue since it was not clear which categories of work below the small purchasing limit was complicated enough to require the efforts of a contract specialist rather than a purchasing agent.

This paper describes both the implementation issues and the progress made in standardizing position descriptions, developing and keeping training programs current, and defining the duties of procurement professionals at various levels.

INTRODUCTION

The last six years have seen some remarkable changes in the way the Forest Service handles its delegations of authority. The organization has made some major changes in the way its contracting and purchasing positions are classified, faced some major objections to its initial policy and made the necessary adjustments, and increased the cooperation between procurement and personnel classification functions while at the same time increasing the effectiveness to its line officers at field locations. The Service has also had to conduct major cooperative ventures with its field units to incorporate their concerns in the policy development and, in some cases, explain in more detail what the objectives were and why the changes would be of benefit to them.

Proposal Summary. Our intention was to move from a very complex authority delegation form to a simpler one that would both permit the increase of dollar delegation at the national forest level while at the same time increasing the confidence that contracting officers and purchasing agents would be assigned responsibility only on actions for which they were trained and capable of effectively representing the government.

Increasing authority at the local level involved increasing required training and doing as much as possible to insure that personnel were properly compensated for the work that they were expected to do. To obtain non-supervisory grade increases at lower organizational levels, the procurement staff had to work with personnel classification to insure that there was clear understanding about how to determine the variation in contract work complexity.

Implementation. It quickly became apparent that the procurement staff had several jobs to do. Once personnel classification and the procurement staff at the headquarters level agreed, it became apparent that both personnel and acquisition field counterparts needed to understand the merits of the proposal. It was also apparent, that some acquisition employees did not operate at the higher levels of expectations that was described in the position descriptions. To obtain approval of the proposal, the agreement of our field line officers was also necessary. To make it work after approval, the support and cooperation of both acquisition personnel and classification personnel was required. On some issues, initial assumptions had to be adjusted. Where these could be made without negatively impacting the important aspects of the proposal, it was done.

While the organization was implementing the changes, it was also increasing the demands on acquisition personnel to use better judgement in the exercise of their duties. The organization was emphasizing the use of negotiations and encouraging everyone to insure that while being fair to all parties, they also used the flexibility available in the decision making process. Since large numbers of Forest Service transactions are below the small purchase level - and many of these on somewhat complex service requirements - emphasis was placed on moving from the constricting sealed bid mentality and moving to a more flexible attitude in this area.

Results. After several years use, it is clear that the proposal works well. We have strengthened and clarified the limits of the career fields for both our contracting and our purchasing personnel. The organization has increased the scope of work that can be done at the national forest locations while increasing the capability of those who do the work. Most of this has been transparent to line officers who continue to be satisfied with the service provided.

CHANGES

Prior System. The initial paper described three types of procurement models including the model used by the Forest Service. Essentially, the Forest Service works on the basis that all work and decisions including those involving acquisition should be accomplished at the lowest possible organizational level. The Forest Service's National Forest System has four organizational tiers: Ranger Districts, National Forests, Regional Offices, and the Washington Office. Procurement is accomplished at all four levels with most of the work being accomplished at the National Forest level and above. Legal assistance, except for the more serious situations, was not, and is not, available below the Regional Office level. When we began, many National Forests had only one Contracting Officer and their training requirements were not clearly defined. Increases in authority were based primarily on time and experience with certain specialty areas such as road and bridge construction, building construction, leasing for space, architect and engineer services, standard services, supplies, and, as a separate authority, the use of negotiations rather than sealed bidding in the appropriate categories. Authority was delegated in fairly small dollar amounts for negotiation and formal advertising in areas such as supply, service, architect and engineer services, building construction, and non-building construction. This was an attempt to define what a particular contracting officer was qualified by training and experience to do. Work that was beyond the defined authority of a particular contract specialist would have to be referred to the Regional Office or another National Forest.

Proposed and Implemented. The proposal was to strengthen the training standards, increase the dollars of delegation, and then effectively manage work assignment at the lowest possible level in order to insure that each individual was properly trained and otherwise prepared for the tasks assigned to them. Another aim of the proposal was to insure that the workers were properly compensated for the difficulty of the work they were doing. There were several concerns that had to be resolved. The issue of fair compensation involved cooperation with personnel classifiers and will be discussed in more detail below. The issue of training was also very difficult because it involved significant increases of training for some people who had been acquisition specialists for some time and also required a heavy commitment on the part of the organization not only for training for new employees but also for the necessary remedial training. That issue will also be discussed as a separate item below. In addition to those issues, we had three major definition difficulties: Construction, Space Leasing, and the dividing line between contracting officer and purchasing agent work.

Construction. There were two major issues in the construction area. One of them related to compensation and will be discussed below in that section. The other related to changes in practice and attitude. Following our complexity analysis (1), we determined that all construction accomplished in the Forest Service was complex enough to require a GS-12 signatory contracting officer. That created some serious problems for some of our field units. Even though they were willing to accept the concept in general, they objected to moving the work responsibility from the national forest offices where a GS-11 contract specialist might be located to the regional office. (2) This was of particular concern within our Eastern Region. The Eastern Regional Headquarters is located in Milwaukee, Wisconsin, and they supervise national forest offices from Minnesota to New England and as far South as Missouri and West Virginia. Administration over that distance, particularly for small contracts, is a serious problem. Upon examination, we found that the concerns could be resolved. Many of the construction tasks that the national forest level contracting Officers were doing involved reconstruction, essentially heavy maintenance, of national forest roads. After much discussion, we determined that the complexity of the work was such that a properly trained GS-11 Contract Specialist could reasonably accomplish the work and also would be properly compensated for the work difficulty at that level.

Space Leasing. The leasing area also presented considerable difficulties. Our authority to do this work is delegated to us and controlled very carefully by the General Services Administration. We have special training requirements as well as an expectation of a high level of on the job experience and professionalism. The people who accomplished this work were all highly skilled and were functioning at the GS-11 level as well as being supervisory GS-12s. Our complexity analysis[1] indicated that space leasing was one of the more complex acquisition tasks that we accomplished. Therefore, we determined that we would limit the delegation of this authority to properly trained and experienced personnel at the GS-12 and above levels. This led to several problems. The first related to simply making the change and saying that GS-11 personnel could no longer sign lease agreements. In some of our regions, there was great resistance to this. Even though we made no restrictions on who could assist with the work, it was still a contentious issue. Within the Forest Service procurement culture a powerful value is that the person who signs the contract should be the one that does the work or conversely the person who does the work should get the "credit" of being the contracting officer or purchasing agent. There was no compromise in this area. It was clear enough to large numbers of people that this work was complex enough to support the GS-12 grade level that the position was supported. The result of this was the increase in grade of some of the leasing contracting officers.

There was another issue in this area that is still being resolved. We are still considering if there are space leasing actions that can legitimately be accomplished at the GS-11 or lower level and, organizationally, at Forest Supervisor's offices rather than the Regional Office. Several examples of potential areas of less complexity involve the temporary leasing of pasture land for fire fighting encampments and the routine leasing of storage space. Some of these issues were resolved by treating simple "rentals" as routine services and by carefully defining what makes leasing complicated and letting less skilled people accomplish this work.[2] This issue was complicated by several factors. First, we had to insure that we did not violate the conditions of GSA's authority delegation to us. Second, we had to insure we did not violate our own standards. Third, we needed to insure that the guidance was clear enough to be used by those in the field who are actually deciding which tasks fell into which categories. This approach has been in place only five months at the time of this writing. At this time it appears to be working well.

Contracting Officer versus Purchasing Agent. This issue can be simply stated: Should purchasing agents serve as contracting officers on all transactions within their dollar authority or not? At the time of our study there was a great deal of variation in the Forest Service. What was done at each location was fairly rigid but there was no consistency between individual national forests, regions, and research stations. In general it worked like this: If a National Forest had a full compliment of Contract Specialists and Purchasing Agents, a GS-12 Contract Specialist probably did most of the construction work including fairly low value construction, unless he or she was too busy. In this case, the work would be assigned to another contracting officer or purchasing agent. In most circumstances, this would be carefully monitored. The GS-12 contracting officer would also, traditionally, accomplish all of the Brooks Bill A&E contracts, and any supply or service contracts that were to be obtained using negotiated procedures.[3] The GS-11 contracting officers were responsible for obtaining all the services and supplies within their authority. These would generally be standard supplies and forestry services such as tree thinning and tree planting. Most of this work was done using sealed bid procedures and many of these contract specialists were not very knowledgeable of negotiated procedures including the pricing of the modifications on their own contracts. Purchasing agents were responsible for standard supplies and simple services within their delegated authority. However, if a national forest did not have contracting officers then the variation was extreme. In some situations, the purchasing agents were expected to accomplish everything that could possibly fit within their dollar authority. Since small purchase authority was delegated and controlled at the regional level this could be very broad. For example, it could include our most complex services such as tree planting or even certain low dollar complex construction projects. Part of our analysis involved separating the work that the Forest Service traditionally accomplishes into seven distinct categories. Some of these were broken into subsets. Essentially each category is described as to the features of the work and some examples provided. Then the minimum level required of the person accomplishing the work is identified by grade level and training required. Finally, a description is provided of who is permitted to judge whether the work falls into the category or not. This descriptive material has permitted us to increase the dollar authority delegated from the Washington Office from relatively small amounts to $1,000,000 at the National Forest level. To help understand the significance of those figures, please keep in mind that these sums are often delegated to contract specialists located in remote areas of the country with no legal or other assistance available to them in their day to day work and decision making. Stated very simply, our procedures now support more consistency in work accomplishment by those properly trained and compensated. In the past, work assignment tended to be determined more by who was available at a particular site. This contributed to both over and under qualified people being assigned work.

COMPENSATION

The concept of proper compensation was difficult to resolve. We were concerned throughout our implementation, not only with adequate preparation to do the job but also with proper compensation. This is clearly closely intertwined with personnel classification issues. Essentially what we did in conjunction with our personnel classifiers was develop criteria for determining which of our standard projects exceeded others enough to be classified at a higher level. We dealt with this in the two areas discussed below.

Contracting Officers. When this project began our National Forest Contracting Officers were classified at one level, the GS-11. Those classified at a higher level were serving as supervisors of other contract specialists or other disciplines to justify their higher grades. It was believed that the contracting specialty within the Forest Service did not support classification at a level higher than GS-12. Those of us that were aware of the range of contracting complexity that we handled did not believe this to be true. We had work that ranged from fairly standard service contracts to difficult construction projects and negotiations for highly technical professional services. To reach our goals of clarification in this area, we had to work closely with position classifiers at the national level and using the Factor Evaluation System develop position descriptions that recognized the varying levels of difficulty at the National Forest level. This had two benefits. First, we were able to recognize clearly the differences between our base level contracts and those that were more difficult. Second, having broken the mind-set of "only one level of difficulty" we were able to properly compensate some Contracting Officers temporarily who were responsible for some unusually difficult projects at both the GS-13 and GS-14 level. Projects of this complexity are unusual within the Forest Service but we at least now have broken the old model so that we can get a more open examination of worth here.

Purchasing Agents. The standard compensation model for Forest Service purchasing agents was at the GS-5 through GS-7 levels. In those few cases where the grades were higher it was generally because of other responsibilities. As mentioned above, there was a great variation in the actual work being accomplished. On some units, the purchasing agents were doing complicated service projects and construction projects below the small purchase limitation and being paid at the GS-7 level. On other units, GS-11 contract specialists were accomplishing similar work. The position of many Forest Service classifiers at that time was that since the standard position descriptions provided in the 1105 position classification standard did not go beyond the GS-7 level that is all that was intended. In addition, the work described came out of a different model (military) and did not relate well to what we were doing. Beyond that we had the old problem of our purchasing agents signing and administering their own contracts and the standard not fully recognizing the additional difficulty and responsibility that meant. In any event, we formed a task group of line officers, requirements personnel, personnel classifiers, purchasing agents, and contract specialists. These individuals were from all organizational levels. As a result of this we accomplished several things. First, we developed standard position descriptions from the GS-5 through the GS-9 level. We developed an appropriate training requirement for all the levels including the work with complex service contracts to be assigned at the GS-8 and 9 levels. We also changed our work assignment policy to clarify which of our service projects were of a suitable complexity to be assigned to a trained purchasing agent at the respective grade levels. One major benefit of this was bringing added clarity to the line manager and helping them decide how to staff to accomplish their work. They could now clearly evaluate whether they wished to have a GS-8 or 9 purchasing agent on a unit and send contracting work beyond that complexity to another unit for award and administration or hire a GS-11 contract specialist and accomplish even more work on the unit. For the first time the guidelines for making this decision were clear.

TRAINING

Contracting Officers. A key element to the strategy of increasing authority at our field locations was requiring training and other necessary preparation. If we were going to expect contracting officers to act independently in isolated locations, we had to insure that they were properly trained. For years, we had basic training guidelines in place. These were carefully reviewed and stringent requirements put in place for each of our four authority levels. These levels now encompassed both dollar amounts and specific supply and service categories. There was some complaints concerning the expense required.[4] We were able to establish and maintain the position that the training was necessary. Although it was a controversial issue for several months with some managers, we were able to insist that they had to choose between adequate training and limitations on unit procurement authority. There were two other difficult issues. Our training program was designed to train a new employee from intake to high levels of procurement authority over a period of many years. We also had to deal with large numbers of contracting officers in place who had varying amounts of training. Some of them had been very well trained. Others were not. We discussed this with our field directors and settled on about a 30 month "catch-up" training period. All contracting officers were "grandfathered" at their current level with the caveat that they become fully trained within a reasonable time period. Each region had to analyze the training of each of their contract specialists and determine what training was needed and then insure that each local line officer and contract specialist understood that if they were not properly trained by the target date their authority would be reduced to match their training background. We encouraged the regions to arrange for regional training sessions where there were large numbers of similar shortcomings. One example of a consistent defect was in the cost and pricing area. As the cut off date approached several regions asked for additional time. Usually there was a good reason for this and we were able to grant it. The second problem in this area related to hires from outside the Forest Service. We discovered that the formal preparation of contract specialists from other agencies, including the Department of Defense, varied widely. Our policy was to accept the individuals at the same level they had been in their previous positions insofar as we could determine that, and then provide a reasonable time period to make up any training deficiencies. This has not presented any particular problems and has worked well.

Purchasing Agents. This area was handled similar to that of the contract specialists. One significant difference is that more on the job training is permitted and encouraged. At the lowest authority levels we require only very specifically targeted training to provide necessary skills in just those areas where someone actually needs it. For example, if the individual is only using a Government credit card, we make no attempt to train them in the use of purchase orders or other such documentation. We greatly increased the training requirements at our highest purchasing agent levels because we now could have purchasing agents doing reasonably difficult negotiations and contract administration on service projects that were below the small purchase threshold. Since much of this work is critical to employee well-being and/or agency mission, we wanted to make sure that they were properly trained to make wise evaluations of quotations on service contracts and also were capable of administering the resultant contracts. Once again, we had complaints about "excessive" training for purchasing agents. Our response, as before, was that if someone wished to have purchasing authority they must be appropriately trained and otherwise prepared to conduct business on behalf of the Government.

ORGANIZATIONAL INVOLVEMENT

Procedure. All of the changes described above took place over several years and there were problems along the way. However, very positive changes were made. This would not have happened without the involvement of many portions of the organization. The Forest Service is a decentralized organization with, in many ways, a weak hierarchical structure. This is to say that subordinate units frequently have to agree with decisions from higher organizational levels or change takes place slowly or not at all. Another way of saying this is that issuing policy is not very effective unless the subordinate organizations have some commitment to carrying it out. In addition, any policies that are unacceptable to line organizations, if they are not ignored, will result in complaints that can result in recision or major change. To minimize the noncompliance or resistance for these changes, we did several things.

Functional. Initially, we held discussions with the Regional Directors and comparable representatives from the Research Stations. These discussions were held to insure that they fully understood our objectives and what the trade- off would be of these changes. Although there was some skepticism, they generally accepted the objectives of the change. Throughout the process we listened carefully to the concerns of these people and made changes when necessary. Those changes will be discussed further below. In addition, we closely involved procurement specialists from our field locations in the development of the training requirements, in the analysis of work complexity, and in the development of the standard position descriptions. We worked very hard to insure general ownership of the final product.

Classification. Much of what we wanted to do required a change in attitude on the part of Forest Service position classifiers. The two viewpoints that were our primary targets were (i)that there was no field contracting officer work more difficult than a GS-11 should do and (ii)that there was no purchasing work more difficult than a GS-7 should do. This attitude is still not wholly changed. However, we have general acceptance of the principal by classification personnel at the Washington Office and also have the standard position descriptions developed and in the Forest Service manual for use. Therefore, anyone who does work as described at the higher levels has a reasonable chance of being properly classified. Where that does not happen, we have the commitment of the Washington Office classifiers to help rectify the situation. This progress came about in two ways. The contracting officer issues were resolved by many one on one discussions with the head Forest Service classifier and developing the necessary data through field work and analysis of the Factor Evaluation System for the 1102 series to show that both the 11 and 12 level were appropriate classification levels. We did learn one important thing here, however. Since this work was done primarily at Headquarters level it was not well understood and actively resisted by some field level classifiers.

From the experience with the 1102 series we decided to approach the purchasing agent (1105) series somewhat differently. When we began work on that series we assembled a task group that included several classifiers from the field level. They were part of the team that developed the position descriptions. We began with a week's meeting in a neutral location with personnel from all organizational levels including line management and field classification personnel. The classification personnel were given a good deal of responsibility for developing the final product. Although it seemed that this process took more time, it probably did not. It moved forward with fewer stops and starts and produced an excellent product. Field level acceptance came with less objection. In fairness, that may be because it has not yet been tested as much. However, some of the acceptance must be based on the additional involvement of the field units in the final product.

Changes. Although the final product (if any product of this nature is ever final) is basically the same as what we proposed, we did make some changes. The first involved the construction area. One premise we began with was that construction contracting was always difficult enough to require a GS-12 signatory level. We encountered two problems with this. One was fairly clear evidence in the Factor Evaluation System that the concept was open to challenge. The other was resistance from several regions that had small units whose primary demand for construction expertise was occasional heavy maintenance on any already constructed road. (See discussion on Construction above.) We discussed and evaluated the input in this area over a considerable period of time. The fear that we had was that weakening the principal would lead to employees being assigned work that they either were not equipped to do or for which they were not properly compensated. We did find an acceptable compromise. Our work assignment policy now states that a GS-11 contract specialist can be the contracting officer on less-complex construction projects when they are below $100,000 in value and the Regional Director agrees that the project is of limited complexity. This protects the principal that the work normally is GS-12 level work and also permits local responsible judgement.

Another problem we encountered was a discrepancy in skill mix between what was required for contract award and what was required for contract administration. During this time period we were encouraging increased use of negotiation procedures where it made sense to do so. However, we required specialized training and experience for the use of those procedures. This created a dilemma for us on those units that were capable of administering a certain type of contract but had no one qualified to make a negotiated award. This was complicated by a policy which, for good but not relevant reasons, severely limited a contracting officer's authority to designate an Adminstrative Contracting Officer. After some reflection, we resolved this issue by permitting award to be made on one unit and administration then to be assigned to another if the new contracting officer (Administrative Contracting Officer) could have awarded the contract had it been awarded using sealed bid procedures. This accomplished several things. It permitted us to keep a protective policy in place. The Washington D.C. Office did not have to be involved in making local decisions. Units could select the negotiation method when appropriate without having to lose local control of administration. This is an important issue for the Forest Service. Many of our contracts require regular on the ground administration. Trying to do that from several hundred miles away or more is not desirable.

Flexibility. An issue both with some Forest Service Managers and some position classifiers was whether our policy was driving either classification or management decisions. Of course, our work assignment policies do that to some extent. The issue for us was to determine at what point were we legitimately protecting the responsibility we had to insure that procurement was accomplished by properly trained people as well as making some efforts to protect the principal of adequate compensation for work being done. When we finished with the policy we had policy and procedures in place that support those principals and still give management a great deal of flexibility. Establishing higher level purchasing agents permitted flexibility that was consistent with procurement standards and still allowed managers to make crucial management decisions. Many Forest Service management units have very limited procurement programs. Given the size of their programs they simply cannot afford to maintain the higher level procurement skills they need on an occasional basis. The new policy broadens their level of choice and still insures that well qualified people will accomplish the procurement tasks. A national forest supervisor can now more reasonably choose to staff with an 1102 contract specialist or with an 1105 purchasing agent. The trade off in terms of training requirements and work that can be assigned locally are clear.

SUMMARY

Strengthened Career Fields. A process that began in 1984 to "insur(e) that work is properly assigned . . . in (a) decentralized organization" encompassed other benefits.[5] By looking carefully at how and to whom procurement work was assigned in the Forest Service, we identified both classification and training problems. By analyzing the training needs of our procurement work force we developed a training requirement that strengthened the ability of not only the new people coming into the area but also most of the work force that currently existed. In addition, by working with Washington Office classification personnel we were able to establish two non supervisory working levels within the GS-1102 and five levels within the GS-1105 series.

Increased Field Level Authority. Before these procedures were put in place, field level authority was severely limited because it was not possible to delegate all the various types of contracts that an isolated contracting officer or purchasing agent might encounter. Now, any fully trained GS-11 contract specialist who needs it can have $1,000,000 of authority to award and administer those contracts that he or she is capable of handling. Small purchase dollar limits continue, of course, to be capped by the small purchasing limit. However, for those purchasing agents who are properly trained and supported we have expanded the types of goods and services that they may procure into areas previously reserved for contract specialists. There have been no serious problems from these changes. We still experience mistakes from contract specialists and purchasing agents at all levels. This is no greater than it [illegible]r was and to some extent we see fewer claims and appeals than we did before due to the increased training programs.

ENDNOTES

1/ Morris, Patrick M., "Contract Complexity and a Decentralized Organization," *Proceedings of the 1985 Federal Acquisition Symposium*, pp. 232-233.

2/ See Forest Service Acquisition Regulations (FSAR) 4G01.675, 8/16/90.

3/ This practice was established and had become routine at most locations prior to the passage of the Competition in Contracting Act.

4/ Prior to first delegation of authority, contract specialists must obtain 216 hours of formal training. Prior to becoming a contracting officer with full authority, 456 hours of formal training is required. See FSAR 4G01.673, 8/16/90, p. 4G01.673-5.

5/ Morris, Patrick M., "Contract Complexity and a Decentralized Organization," *Proceedings of the 1985 Federal Acquisition Symposium*, p.230.

TEAM SUCCESS IN AN AIR FORCE PROGRAM OFFICE

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ABSTRACT

It would be remarkable if we could speculate--with some degree of accuracy--how a small group of people might perform assigned team tasks, and if all of this could be done in the environment of a weapon systems program office.

We can and we have, both in the laboratory (1989 Acquisition Research Symposium paper and presentation), and now operationally in the field at thec Air Force's Aeronautical Systems Division (ASD).

Faculty members at DOD's National Defense University assessed over 150 military officers and civilian government professionals at ASD's Electronic Combat and Reconnaissance SPO--14 "basket SPO" teams ranging in size from 3 to 16 people each.

Senior members of the Systems Program Office (ASD/RW) at Wright-Patterson AFB became aware of the prior research at National Defense University and inquired about "operationalizing" it in their SPO. The primary area they wished to pursue was:

> Are there ways in which we can differentiate between high performing teams and those that don't perform as well, using psychological type as the yardstick?

The possibilities for the acquisition community are profound, since research of this nature has not been accomplished before. We all know that program managers want to get the best out of their people, whether it's a special task force or a working team in the PMO. This study has the potential of being one of those forward-looking vehicles to enhance that possibility.

Where are we in the broader research effort? The "concept exploration" phase of the project was completed in 1987, and now we're operationally testing small work groups in a PMO environment to further validate the concept.

Many questions arise about the research: Does it make any difference what type people are on a team? Do certain groupings of people in the PMO environment achieve better (or worse) performance than others? Is there a "collective" nature about group members and their individual types? Do any relationships (correlations) exist between performance and the characteristics of groups?

So far, all of these have come out "yes."

INTRODUCTION

There is the thought that a small group of people has a "collective" sense about it, i.e., that assertions can be made about the functioning and performance of a group and the psychological type of its members. It's been further hypothesized that a relationship exists between a group's performance and its collective psychological nature.

There is a sizeable collection of research and literature on the subject of the Myers-Briggs Type Indicator (MBTI) as it relates to the individual. There are also numerous volumes on groups and group dynamics. But there is a relative paucity of research on the "intersection" of the two: Personality--as measured by psychological type--and Groups.

Extravert	0 ...	Introvert
Sensing	0 ...	Intutitive
Thinking	0 ...	Feeling
Judging	0 ...	Perceiving

The Four MBTI Dimensions

For each MBTI dimension--EI, SN, TF, and

JP--a team's average continuous score[1] was computed. Mean continuous scores allowed the classification ofteams into a "collective" MBTI. Similarly, the standard deviation (as a measure of a team's diversity) was computed for each MBTI dimension for each team.

Three Years Ago. In the 1986-87 time period, the relationship was investigated between group psychological type and the performance of 50 small groups working on the same, measurable task.[2] The participants--220 senior military officers and civilians at the Industrial College of the Armed Forces (ICAF)--were divided into four and five person groups.

Each team took a missile system program from concept exploration through production and deployment. They encountered many of the same decisions that would be made in a real program office. The difference was that each of the 50 teams were structured by psychological type using the Myers-Briggs Type Indicator (MBTI). Team performance on the exercise was measured, then compared with how well they fared against one another. A relationship (correlation) between the (MBTI) variance of people in a group and the group's performance was established.[3]

Today: An ASD SPO. More recently, members of the Electronic Combat and Reconnaissance SPO (ASD/RW) at Wright'Patterson AFB, became aware of this prior research and inquired about "operationalizing" it with officers in their SPO"over 100 military officers and civilian government employees. The areas they wished to explore were:

1. Are there ways in which teams can be differentiated between high performing ones and those that don't perform as well, using psychological type as the yardstick?

2. In making this determination, are there ways in which teams can improve their capability"regardless of where they are on the performance spectrum"by learning something about how groups operate?

Additionally, our research team wished to explore other areas:

1. Does having the same (or different) psychological types on a team enhance (or detract) from a team's performance?

2. Can anything be said about a group's performance where members have similar (or different) MBTI preferences?

3. How about specific MBTI preferences? Do some do better than others on various aspects of group work?

Survey instruments were administered to SPO team members as well as to line and staff supervisors. The second of the two"the one on which this paper focuses--was for (a) supervisors having responsibility for a number of teams, and (b) other staff members who know the characteristics and performance of the teams, but not having supervisory responsibility. "Team success" in this research was based on the input of 16 senior managers **and** the MBTI results of the members of 14 products teams.[4]

Teams were ranked ordered in terms of:

1. Team Tasks - What the team does. It's performance (goals, objectives, productivity, output).

2. Team Process - The way the team works together (communications, problem'solving, procedures).

3. Group Characteristics - Other factors that influence the way the team operates. Similar to "Team Process" above, but rather the factors--the "intangibles"--that cause the team to operate as it does (teamwork, skills, commitment, conflict, interest level).

4. Overall - the bottom line; how the teams rack up compared with each other.

The basic idea of this research was to continue exploration of the 1987 concept--the idea that a small group of people had a "collective" psychological type. The purpose of the study was to evaluate psychological type and its relationship to group performance/success.

ANALYSIS

Team Performance and Diversity. In the 1987 research, the standard deviations (s.d.) of continuous MBTI scores for teams were correlated with performance. The relationship of team performance with this measure of team <u>dispersion</u> on each of the MBTI dimensions is shown below:

Preference	r_s	p<
Extravert-Introvert (EI)	-.24	.1
Sensing-Intuitive (SN)	.35	.01
Thinking-Feeling (TF)	-.33	.025
Judging-Perceiving (JP)	-.07	--

Three of the four were negative, i.e., as the standarddeviation--team dispersion --increased,performance decreased. Said another way, as team members became more alike on the EI and TF dimensions, i.e., where scores clustered closer and closer to one another, performance increased.[5] Conversely, teams whose members displayed wide swings in continuous scores on EI and TF seemed to have performed less well.

A question that continues to surface is how good is good in correlation. A rough rule-of-thumb for evaluating the magnitude of a correlation coefficient is: "a correlation that is less than 0.30 is small, a correlation that is between 0.30 and 0.70 is moderate, and a correlation that is between 0.70 and 0.90 is large...." It should be added that although such rules provide a guideline, they can be misleading in specific situations. One really must know what is typical.[6]

One correlation was positive. As the standard deviation of MBTI continuous scores on the SN dimension increased, performance increased. Despite several hypotheses derived from observing the data, no statistically significant conclusion could be drawn that fully explains this relationship. One explanation for this was that a broader range of learning methods on a team provided for a breadth of understanding of issues being worked.

Successful Teams and Diversity. Team success as evaluated by the SPO's senior officers at Wright-Patterson Air Force Base was correlated with a team's standard deviations (s.d.) of continuous MBTI scores. The relationship of this measure on each of the MBTI dimensions is shown below:

Preference	r_s	p<
Extravert-Introvert (EI)	.38	.2
Sensing-Intuitive (SN)	-.42	.2
Thinking-Feeling (TF)	.05	--
Judging-Perceiving (JP	.25	.4

Three of the four were positive, i.e., as the standard deviation--team dispersion--increased, a team was designated more successful by the cadre of senior officers that evaluated them. Said another way, as team member scores clustered closer and closer on the EI and JP dimensions, team success was not apparent. Conversely, teams whose members displayed wide swings in continuous scores on EI and TF seemed to perform better.

One correlation was negative. As the standard deviation of MBTI continuous scores on the SN dimension decreased, team success was more evident. This is the largest correlative factor in the research.

LOOKING AT THE OUTCOME

EI Dimension. Results are explained by recalling the definitions of extravert and introvert. Extraverts prefer processes in the outer world of people and things. Introverts favor work in the inner world of concepts and ideas. The acquisition process"particularly during the early phases--exists on a conceptual plane. It is not yet the real world of actual things and people, but rather a future world of ideas and capabilities to come.

The SN Dimension. Sensing types are good at gathering facts. However, Intuitives deal with meanings, relationships, and possibilities that are beyond the reach of the senses. Again, the nature of the acquisition process seems to demand the natural propensity of the Intuitive toward dealing with the abstract. Systems not yet in existence are more difficult to "sense" for the Sensing type. Conversely, Sensing types appear to have an advantage the further along a system is in the acquisition life cycle.

The TF Dimension. Since the weapon systems acquisition process is one of decision-making, the TF dimension is an appropriate one to focus on. Thinking types like analysis and putting things in logical order. They tend to decide impersonally, sometimes paying insufficient attention to people's wishes; they are more analytically oriented. The pure acquisition process offers the textbook opportunity for dispassionate analysis"a task befitting a Thinking type. One could theorize that in a group of mostly Ts, performance would be associated with a measure of the group's Thinking dimension.

The JP dimension. The relationship on the JP dimension can be crucial. Judging types like to focus on a problem and come to closure. Perceiving types prefer diverging--gathering more information and keeping options open. Judging would seem to be in greater demand later in the problem solving process, offering a propensity for closure, execution, and implementation. Teams tending more to Perceiving than Judging would possibly perform better early'on in the weapon systems acquisition life cycle. There appears to be a greater tendency to explore alternatives among teams with a preference for Perception.

The Best and the Worst Teams. The team denoted as First or the best of the 14 was evaluated by senior officials as being significantly better than all others. Conversely, the one that resulted in having the lowest or Last evaluation was significantly worse than all others.

Last — First

X X XX X XX X XX X

Range of Team Success

How did the First or best team differ from the Last or supposed worst team on their composite MBTIs? The difference of greatest significance was on the JP dimension. The First team's dispersion (s.d.) was the largest of all teams"and the Last team's the smallest. Said another way, members of the Last team were psychologically alike, which means they were homogeneous on this dimension"as they were on the TF dimension, too.

SUMMARY

Three years ago--the "concept exploration phase" of looking at psychological type **and** small groups concurrently--was the **first** time anyone anywhere attempted this. The current effort might best be labeled the "demonstration/validation" phase. It was a real-world effort at a military location"Aeronautical Systems Division"the firing line of the acquisition business.

The "Dem/Val" results are both bad and good news in the eyes of the authors. All of the standard deviations are <u>opposite</u> the "C/E" phase results. The good news is that they are significantly large enough to warrant further scrutiny.

	3 Years Ago	ASD SPO
Extravert-Introvert (EI)	-.24	.38
Sensing-Intuitive (SN)	.35	-.42
Thinking-Feeling (TF)	-.33	.25
Judging-Perceiving (JP	-.07	.25

The best and worst--the most and least successful--teams in the SPO have the potential of reawakening the homogeneous vs. heterogeneous group debate, and the kinds of groups that are successful and most productive. By a sizeable margin, theorists that study groups reside on the side of group member diversity and success of groups in their assigned tasks.[7] This substantiates our most recent results even more. Although members of heterogeneous groups expend more energy because of their differences, they are apparently more successful in their team tasks. Again, the "Dem/Val" research supports this.[8]

Some managers support the theory that heterogeneous groups produce more alternatives and better quality decisions than homogeneous ones. They acknowledge that, although groups with diverse membership structure may expend more energy during the formation process, the end product is enhanced as a result of a group's diversity.[9]

A conclusion of this research is that we concur with this notion. Our overall results, but particularly the ones between the best and worst teams on the TF and JP dimensions, support the idea that diverse working groups are better producers than homogeneous ones.

The authors acknowledge that there are limits to this study: it was conducted in a specific environment--the Aeronautical Systems Division--and with a unique sample- military officers and government executives. This is obviously a unique, contextual group of people. Nonetheless, there are extrapolations from the data that raise serious questions appropriate for continuing research. One in particular relates directly to the military and program office environment.

CONCLUSIONS

The potential for this type research in the acquisition community is enormous, primarily because it's not been looked at this way before. It's a recognized fact that PMs want to get the best out of their people, whether it's a special working group or an ad hoc task force"or just the customary group interacting in a PMO. This concept has the possibility of being one of those forward'looking vehicles to enhance the critical and productive use of manpower in the military program office.

Where is this type of small group research going? The "concept exploration" phase of the project was completed three years ago, to include the first "qual test." The current research is the first operational prototype with small work groups in an authentic PMO setting that further validates the initial concept and preliminary findings.

The bottom line is that the jury is still out on the validation of this hypothesis. However, it should be concluded that MBTI diversity is definitely a commodity that differentiates teams. In what direction, small or large, is still uncertain.

A repeat of this most recent "Dem/Val" phase is in order. However, it must be a larger, controlled study with a greater number of teams. This is needed to validate the hypothesis that there is a relationship between the psychological type of team members and team success.

Said another way: There are numerous horse'droppings all around the pasture we've been working in, so there has to be a pony here somewhere. Our objective? Find the pony, give him a name, and get something useful from him.

ENDNOTES

1 So that researchers do not have to carry alphabetic symbols (E, I, etc.) in their research computations, a single number is used to denote the valuation of an individual's preference. This is known as the 'continuous' score and is simply a transformation of the 'preference' score. It's accomplished by setting the midpoint at 100 instead of at o. For example, a preference score of E-21 becomes a continuous score on the EI dimension of 79; an I-31 becomes a 131. This conveniently eliminates the need to carry alpha characters in statistical analyses. (Myers, Isabel Briggs, and McCaulley, Mary H., Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator, Consulting Psychologists Press, Palo Alto, CA, 1986, pp. 224-226).

2 1989 Acquisition Research Symposium Paper.

3 It's interesting to not that in the conclusions of the 1987 research, the performance evaluation method used would have been modified. It's also noteworthy that the subjects of the earlier research effort were not "PM" people, yet they were evaluated doing a PM job. The subjects in this exercise are in fact program management experts, doing program management work.

4 The following analysis must be labeled "preliminary" because (a) only 16 of the 19 senior officer inputs had been received and analyzed at the time of this writing, and (b) only 76 of 112 members of the 14 product teams had submitted their MBTIs. This is critical to the analysis because, although the correlation coefficients are not expected to change, the resulting probabilities/confidence levels will improve dramatically as the sample size of both--team evaluations and member information--are increased.

5 The sum of the standard deviations on the EI and TF dimensions produced one of the highest associations found in the study [r_S = -.39, p<.005].

6 Jaeger, Richard M., Statistics, A Spectator Sport, SAGE Publications, Beverly Hills, CA, 1982, p. 74.

7 Robbins, Stephen P., Organizational Behavior, 3rd Ed., Prentice-Hall, Englewood Cliffs, NJ, 1986, p. 190.

8 It gives greater substance to Lawrence's supposition that teams operate on a zig-zag of psychological functions, i.e., a balance of all four functions (S, N, T, and F) are required for successful/optimum team performance (Lawrence, Gordon D., People Types and Tiger Stripes, Center for Applications of Psychological Type, Gainesville, FL, 1982, p. 58).

9 The underlying assumption is that a group has only a finite amount of energy available to it and any energy available to the group task (Shaw, Marvin E., Group Dynamics: The Psychology of Small Group Behavior, New York, McGraw-Hill, 1971, p. 400).

THE CONTRACT MANAGEMENT SIMULATION: A TOOL FOR LEARNING

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ABSTRACT

Adults learn best when they perceive that what they are learning is of value to them. Adult learning primarily is self-motivated with a strong emphasis on application. This suggests that the optimal learning environment involves elements of real-life experiences and integrates "learning by doing" with theoretical concepts.

It is within this context that the Business Education and Educational Research Departments at the Defense Systems Management College, Fort Belvoir, Virginia and the Management Simulation Project Institute have undertaken the development of a one-day simulation focusing on contract management issues. The simulation highlights the interpersonal dynamics that occur among key actors in the contract management arena. Organizational interrelationships, power, strategic planning, and decision-making practices and procedures are analyzed and explored.

It is through identifying important issues, collecting and sharing information and interfacing with others that we learn to become more effective managers.

Designed to cover a six hour session, the simulation involves three hours of performance, and three hours of extensive feedback. Additional efforts are focusing on the inclusion of special modules to allow for use with participants demonstrating a wide range of knowledge and experience in contract management.

INTRODUCTION

Background. Recent research on adult education verifies that adults learn best when they perceive that what they are learning is of value to their lives and/or work environments. Adult learning primarily is self-motivated with a strong emphasis on application. Facilitators and/or instructors, at best, can serve as a guide in helping adults learn for themselves.

This suggests that the optimal learning environment involves some elements of simulating real-life experiences as closely as possible, and integrating "learning by doing" with theoretical concepts.

It is within this context that the Business Education and Educational Research Departments at the Defense Systems Management College, Fort Belovir, Virginia in conjunction with the Management Simulation Project Institute have undertaken the development of a one-day simulation focusing on contract management issues.

During the past six years, the Educational Research Department has offered "Looking Glass", a management simulation, as an elective to the students of the 20 week Program Management Course, and as a required component of the Executive Level Courses offered at the Defense Systems Management College. Student and faculty response has been most positive, encouraging the development of a simulation as an instructional tool in the two-week Systems Acquisition for Contracting Personnel (SACP) course mandated for contracting personnel assigned to a major systems acquisition or who devote 50 percent of their time to a major system.

Conceptual Foundation. Behavioral simulations have proven to be valuable educational tools that can concentrate in a short period of time what might take much longer to learn on the job, or in another educational environment. It is an intensive experience, emphasizing "learning by doing" rather than another vicarious approach. Generally, behavioral simulations involve a variety of roles, each related to the broad issues undergirding the simulation. Each role contains extensive information on past activities and decisions and correspondence on current issues, problem symptoms, and decision situations. It is through identifying important problems, setting priorities, sharing information and interacting with others that one can manage more effectively.

Behavioral simulations are tools - or rather vehicles - through which the interpersonal dynamics among people can be highlighted, as strategic and operating issues are addressed-- issues involving integration among work units, power, and decision-making. Today, most, if not all, organizations compete for dwindling resources, vie for a limited market, and continue to be required to "do more with less". Managers must face the paradox of balancing the need to resolve daily operational demands with long-term strategic issues. Behavioral simulations provide realistic learning environments which allow participants to receive feedback on how these challenges are met. The on-going need for additional data; the application of strong written and oral communication skills; the setting of priorities and specification of goals; and the management of conflict are all part of a well-designed behavioral simulation.

Program Design. The design of a behavioral simulation is critical. To be effective, the design must be compatible with the goals and objectives of the simulation, and the overall program within which the simulation is nested. At best, behavioral simulations are tools; the value is achieved when well integrated with the concepts, goals and objectives of an overall program.

There are many design considerations for a program which uses a behavioral simulation. Some key considerations include: what educational training needs are to be satisfied? How much time is to be allotted to the behavioral simulation? What pre-reading is required? What special logistical arrangements are to be considered? How will follow-up and outcome/impact assessments be conducted? How many players are needed? What kind of facilitating skills are needed?

THE CONTRACT SIMULATION

Simulation Overview. It was within the above indicated contexts that the contract simulation was developed. It focuses on the interpersonal dynamics that occur among selected key actors in the contract management arena, (Director of Contracts, PCO C-130 Conversion, PCO New Cargo Aircraft, Contractor, Program Manager). Key objectives of the simulation are to:

1. Identify and analyze the management issues involved in contract administration;

2. Develop a strategy for a follow-on acquisition, taking into consideration the constraints, guidance, direction present;

3. Gain a better understanding of the nature of managerial work;

4. Assess one's abilities to perform as a manager;

5. Develop an understanding of the systematic nature of weapon system program acquisition.

In addition, it addresses such strategic and operating issues as negotiations, selection, scheduling, revisions, and legal implications. Organizational interrelationships, power, strategic planning, and decision-making practices and procedures are analyzed and explored. Because one of its major goals was to focus on the substance issues of contracting, the following issues were incorporated into the design: Reduced Funding, Accelerated Initial Operating Capability, Source Selection, Competition, Contract Type, Data Rights, Late Delivery, Subcontractor Problem, Constructive Change, Overage Change Order, Negotiation Stalemate, Freedom of Information Request, Latest Revised Estimate Variance, Scope of Work, Dispute, Defective Pricing, Disapproved Purchasing System.

Once roles and situations/issues were established, information on previous events and correspondence and data on current issues, problem symptoms, and decision points were provided. An extensive review of actual contracting issues was conducted by the design team and content area specialist to ensure a credible behavioral simulation.

Designed to cover a six hour session, the simulation involves three hours of performance, and three hours of extensive feedback. In addition, participants complete a series of inventories to assess their perceptions related to managerial and problem-solving competencies. Additional efforts are focusing on the inclusion of special modules to allow for use with participants demonstrating a wide range of knowledge and experience in contract management.

Implementation. A field test was conducted with participants currently working in contracting in a program management office, and who would be at about the same level of those participating in the SACP course* for whom the simulation was designed. As a result of the field test, revisions were made in some of the post-simulation processing procedures. The substance of the behavioral simulation was validated by the field test participants and the facilitators, and remained unchanged. Currently, the simulation has been incorporated into the SACP course, and is offered during the first part of its second week. This is based on the premise that the first week is devoted to content, with the simulation serving (1) as a way to assess the degree to which cognitive learning has occurred; and (2) as a vehicle for guiding the remainder of the course. In addition to an extensive content-focused feedback session, participants received facilitator and peer feedback on group and individual behaviors.

Conclusion. In conclusion, the post-simulation assessment and feedback data, from participants, facilitators and faculty responsible for the SACP course and the contracting functional area indicate that the simulation is indeed a viable learning tool. Additional consideration needs to be given to providing a smooth transition between the content and behavioral elements in processing the simulation and the issue of a heterogeneous participant population (ranging from no experience to senior level responsibility in contracting) continues to plague the design team. Plans call for training the content instructors to serve as process facilitators as a way of integrating process with content, and for offering the simulation as an elective to Program Management and Executive Management Course participants.

* These are people with some contracting experience at the GS 13-15 level.

PROGRAM MANAGEMENT

from A to Z

COST PERFORMANCE INDEX STABILITY - FACT OR FICTION?

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ABSTRACT

The Cost Performance Index (CPI) is used by contractor and Government analysts to evaluate cost performance on defense contracts. In particular, the CPI is considered an important tool for evaluating the health of a contractor's management control systems and for judging the credibility of estimated final costs. Although it has long been asserted that the CPI is stable once a contract is fifty percent complete, an exhaustive literature search did not identify any published empirical evidence that supports the assertion. Based on cost performance data submitted by Air Force contractors, this study is the first to document the stability of the CPI.

INTRODUCTION

General Issue. The Cost Performance Index (CPI) is a key indicator used to analyze cost/schedule performance data reported by defense contractors. It has long been asserted that the index does not change by more than ten percent once the contract is fifty percent complete [2:1]. A stable CPI is evidence that the contractor's management control systems, particularly the planning, budgeting, and accounting systems, are functioning properly [3,9]. A stable CPI may thus indicate that the contractor's estimated final costs of the authorized work, termed "Estimate at Completion," are reliable. In addition, knowing that the CPI is stable may help the analyst evaluate the capability of a contractor to recover from a cost overrun by comparing the CPI with other key indicators, such as the To-Complete Performance Index [1,7].

A thorough literature search revealed no published study supporting the assertion that the CPI is stable beyond the fifty percent point, although it may have been based on work done by the General Accounting Office in the 1970s. One expert in cost/schedule performance analysis doubts that the GAO study ever existed [4]. Given the importance of a stable CPI, and the lack of any published evidence supporting the assertion, this study investigates CPI stability.

Background. The CPI is one of several indicators used in the evaluation of a contractor's performance. It is calculated from data that the contractor provides monthly in either the *Cost Performance Report* (CPR) or the *Cost/Schedule Status Report* (C/SSR). DOD Instruction 7000.10 requires that a CPR be submitted for contracts which require compliance with DOD Cost/Schedule Control Systems Criteria (C/SCSC) [5:2]. For contracts not required to comply with C/SCSC, the C/SSR is usually required.

C/SCSC is a set of criteria designed to define an adequate contractor cost and schedule management control system [6]. The criteria are not a management system. Instead, they describe or establish minimal standards for the management control systems used by the contractor, and have two objectives: (1) for contractors to use effective internal cost and schedule management control systems; and (2) for the Government to be able to rely on timely and auditable data produced by those systems for determining product-oriented contract status [6:v]. Implicit in these objectives is the assumption that if the contractor's management control systems comply with the criteria, then the data generated by those systems will be reliable. For a detailed description of these criteria, see the *Joint Implementation Guide* [6].

Data summarizing a contract's "product-oriented status" are reported in the CPR or C/SSR. Key elements include Actual Cost of Work Performed (ACWP), Budgeted Cost of Work Scheduled (BCWS), and Budgeted Cost of Work Performed (BCWP), Budget at Completion (BAC) and Estimate at Completion (EAC). It is from these data elements that the CPI and other performance indexes are derived. For a detailed definition of these elements see the *Joint Implementation Guide* [6].

An analysis of these basic data elements provides the Government with information having both predictive and feedback value. First, using the basic data elements from a CPR or C/SSR, the analyst can compute an independent EAC for comparison purposes. The reasonableness of the contractor's estimates can thus be assessed by computing independent EACs. Second, through detailed variance analysis the Government is able to continuously identify problems and monitor remedial actions taken by the contractor. As expressed by one Government analyst, an identified problem might not be completely solvable, but variance analysis can at least forewarn management of schedule slips and potential cost overruns in enough time to initiate some corrective action [10].

In the process of transforming the contractor's reported data into information, numerous performance ratios may be computed [7:12-15]. Two ratios important to this study are the Cost Performance Index (CPI), and the To Complete Performance Index (TCPI):

$$\mathrm{CPI} = \mathrm{BCWP/ACWP} \tag{1}$$

$$\mathrm{TCPI} = \frac{(\mathrm{BAC-BCWPcum})}{(\mathrm{BAC-ACWPcum})} \tag{2}$$

The CPI indicates the cost efficiency with which contractual work has been accomplished. A CPI less than one implies a cost overrun; more than one implies a cost underrun; and unity implies an on target condition. The values for BCWP and ACWP can be monthly, cumulative, or average, as long as they are consistent. The analyst must decide which values to use.

The TCPI represents the efficiency level that the contractor must achieve in the remaining work to meet the budgetary goal. In Equation 2, the budgetary goal is BAC. If the budgetary goal is another number, such as the Contract Budget Base (CBB), then the numerator in Equation 2 should be changed, where CBB is substituted for BAC. The analyst must again decide what budgetary goal is appropriate.

The importance of a stable CPI. A stable CPI has relevance to the information generated by Government analysts. First, the CPI is heavily weighted in several of the formulas that generate EACs. One expert claims that the CPI is used in many EAC formulas because of its asserted stability [2:1]. Second, a stable CPI is evidence of criteria-compliant management control systems. For example, a stable CPI is evidence that variances are being identified at appropriate detailed levels and are being corrected in a timely and effective manner.

Third, if the CPI is stable, then it has significant value as a bench mark for comparison with the TCPI. For example, if the TCPI is significantly larger than the

CPI, the contractor will have to significantly improve the efficiency of the remaining contractual effort. Clearly, if the CPI is stable after a contract is 50 percent complete, and is significantly less than the TCPI, then it is unlikely that a contractor will be able to meet the budgetary goal, despite any optimistic claims of the contractor. (A respected analyst at the Office of the Secretary of Defense asserts that the 50 percent complete point is too conservative, and suggests that a contractor experiencing a cost overrun at the 15 to 20 percent point will not be able to recover [1]).

METHODOLOGY

Hypothesis testing. The hypothesis tested was:

Once a contract is fifty percent or more complete, the CPI is stable.

CPI stability was defined and measured two ways. First, the range of the CPI was computed for each contract as the difference between the minimum and maximum CPI achieved after the contract was 50 percent complete. For a given contract, a range of less than .20 defined a stable CPI; otherwise, the CPI was defined as unstable. Second, an interval of plus and minus ten percent of the CPI computed at the 50 percent point was calculated. For a given contract, a CPI was defined as stable if it stayed within the interval; otherwise, the CPI was defined as unstable. In addition, the sensitivity of the results were tested against earlier points of completion (40, 30, 20, 10, and 0 percent) and narrower intervals (7.5 and 5.0 percent).

The database. The database used in this study was obtained from the cost library of Air Force Systems Command Aeronautical Systems Division (ASD), and consisted of cost performance data from 26 CPRs for seven aircraft procurement programs. Funding and time constraints restricted the study to seven aircraft programs at ASD that had been "completed." In this study, a completed program (1) had a CPR designated as the final CPR, or (2) was at least 95 percent complete, or (3) was one in which the last aircraft had been delivered. Basic data elements collected from monthly CPRs included BCWS, BCWP, ACWP, BAC, and date (month and year of the CPR). All data elements were taken from the total line of the CPR. Because some of the data are proprietary, the data are not reported in this study.

Five of these seven programs included more than one series of CPRs. The different series of CPRs were needed to capture cost performance data during different phases of the aircraft program. For example, if the program had a separate development phase, there was a separate CPR series for that phase. Table I lists the seven aircraft programs included in the database. The table also includes the dates of the initial and final CPR for each CPR series included in the database. The period of performance for these programs ranged from December 1966 to March 1989.

Defining percent complete. Changes in CPR reporting and contracting philosophy were evident in the CPRs covering these 22 years. Specific differences between programs due to CPR reporting are detailed elsewhere [8]. The differences created a problem in calculating the percent complete for a program. When a program was structured by lot, and there was a separate CPR series for each lot, the monthly percent complete (BCWP/BAC) progressed at an even rate over time. This was because BAC did not change significantly over the life of the lot. However, for programs with only one

TABLE I

AIRCRAFT PROGRAMS INCLUDED IN STUDY

Contract	Initial CPR	Final CPR
A-10 Program		
FSED	Mar 1973	Aug 1978
Option 1A	Jan 1975	Jul 1977
Option 2A	Sep 1975	Jul 1977
Option 3/4	Jun 1976	Apr 1978
Option 5A	Dec 1976	Apr 1979
Option 6A	Dec 1977	Apr 1980
Option 7A	Jul 1979	Apr 1981
B1-B Program		
Production	Apr 1982	Dec 1989
C-5A Program		
FSED	Feb 1967	Feb 1972
Production	Dec 1966	Feb 1972
C-5B Program		
Production	Oct 1982	Apr 1989
F-111 Program		
RDT&E	Dec 1966	Jul 1973
Production	Nov 1967	Sep 1976
F Model 72-75	Sep 1972	Nov 1975
F Model 74-75	Mar 1974	Feb 1977
F-15 Program		
Thru Wing I	Mar 1970	May 1979
FY 75	Sep 1975	May 1979
FY 76/7T	Sep 1976	Dec 1979
FY 77	May 1977	Mar 1981
FY 78	Aug 1978	Apr 1982
F-16 Program		
FSED	Jan 1975	Jun 1981
FY 80	Dec 1980	Jul 1982
FY 81	Oct 1981	Jul 1983
FY 83	Oct 1983	Apr 1986
FY 84	Nov 1983	Feb 1989
FY 85	Nov 1984	Jan 1989

CPR series, the BAC would change dramatically when additional aircraft were added to the contract. For example, with the addition of new effort, the percent complete in the B-1B Production Program dropped from 67 percent complete to 48 percent complete in one month.

To test the hypothesis, the CPI must be associated with a consistent percent complete. When percent complete is allowed to vary with program changes, this consistency is destroyed. Therefore, to insure consistency, the final BAC from each CPR series was used, and percent complete is defined as follows:

$$\text{Percent Complete} = \frac{\text{BCWPcum}}{\text{Final BAC}} \qquad (3)$$

Of course, the results were checked for sensitivity to this definition. Data for each contract were entered into an electronic spreadsheet. The CPI was calculated using the cumulative BCWP and ACWP according to Equation 1. Percent complete was calculated using the cumulative BCWP and the final BAC according to Equation 3.

RESULTS

CPI range. As detailed in Table II, the hypothesis was confirmed. The CPI range was stable from the 50 percent completion point. For various levels of percent complete, the table shows the number of contracts found to be stable (i.e., the range was less than .20); the total number of contracts; and the maximum, minimum, mean, and standard deviation of the ranges observed. (In going backwards from the 50 percent complete point, the total number of contracts varies because there were some contracts which did not have any observations in the next interval.)

Figure 1 is illustrates the same data. For each level of percent complete, the vertical line represents the difference between the maximum and minimum ranges. The top of the line is located at the value of the maximum range, and the bottom of the line is located at the value of the minimum range. The horizontal tic mark on each line is located at the value of the mean range. The term "initial percent complete" refers to all those CPIs that lie between the stated percent complete and the end of the contract.

CPI interval. As detailed in Table III, the hypothesis was again confirmed. The CPI interval did not change by more than 10 percent from the CPI measured at the 50 percent complete point. The table also shows the number and percentage of contracts with stable CPIs at intervals of 7.5 and 5 percent. Other percent completion points (40%, 30%, 20%, 10%, and 0%) are also listed.

Analysis. Based on the CPI range test, the CPI was stable (less than .20) for all contracts from the 50 percent point. Sensitivity analysis shows that the CPI was also stable for all contracts from the 40, 30, and 20 percent points. At the 10 percent point, the CPI was stable for all but one of the contracts. The assertion of the OSD analyst regarding CPI stability at levels much sooner than 50 percent complete is thus supported.

Based on the CPI interval test, the CPI was stable (+/- 10 percent interval) for all the contracts at the 50 percent point. Sensitivity analysis revealed that all but one contract was stable at tighter intervals (+/- 7.5 percent) at the 50 percent complete point. For the other percent complete points, the percentage of contracts with stable CPI intervals decreases as the percentage complete decreases.

TABLE II

CPI RANGE STABILITY

Percent Complete	0%	10%	20%	30%	40%	50%
Total Contracts	19	25	25	25	25	26
Contracts w/stable CPI	10	24	25	25	25	26
Percent Stable	53%	96%	100%	100%	100%	100%
Maximum Range	0.719	0.206	0.163	0.123	0.108	0.093
Minimum Range	0.031	0.030	0.016	0.015	0.015	0.015
Mean Range	0.236	0.092	0.076	0.060	0.052	0.044
Standard Deviation	0.152	0.047	0.042	0.027	0.023	0.019

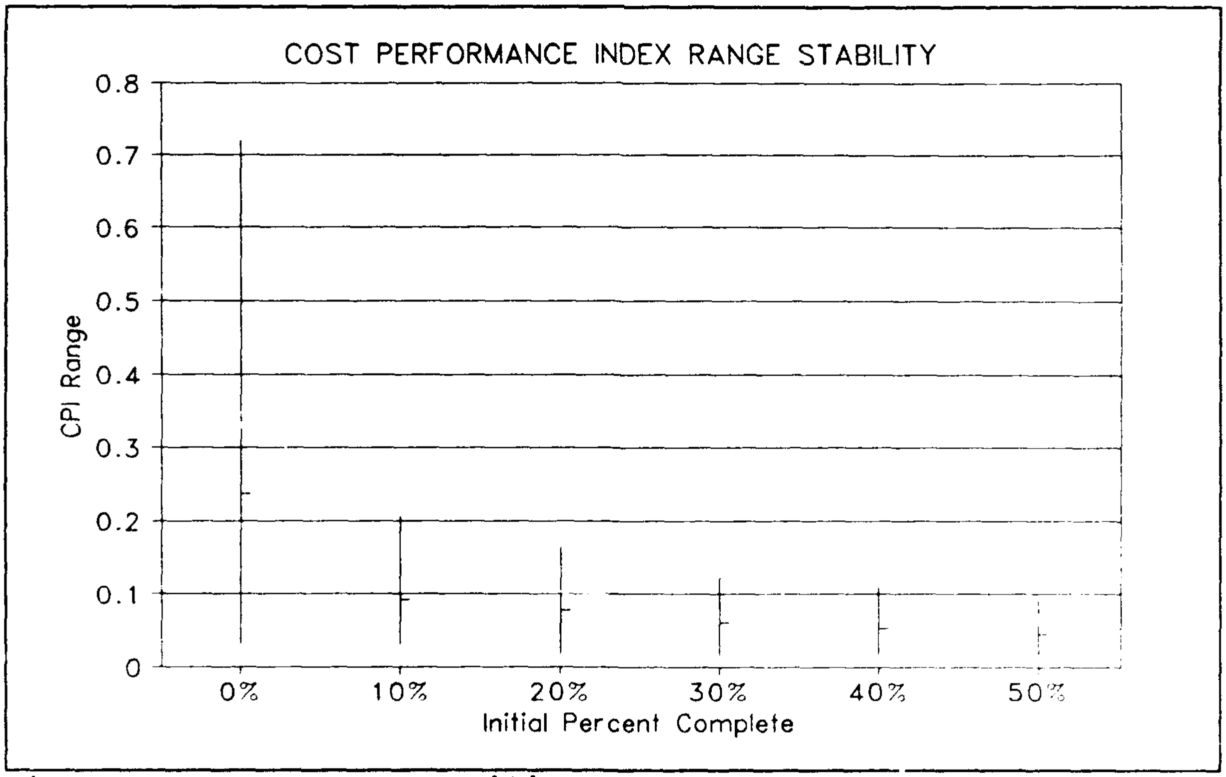

Figure 1. CPI Range Stability

TABLE III

CPI INTERVAL STABILITY

	Based on CPI at 50% complete		
Percentage Interval	10.0%	7.5%	5.0%
Number of Contracts	26	26	26
Number of Contracts with Stable CPI	26	25	21
Percent of Contracts with Stable CPI	100%	96%	81%
	Based on CPI at 40% complete		
Percentage Interval	10.0%	7.5%	5.0%
Number of Contracts	25	25	25
Number of Contracts with Stable CPI	24	23	16
Percent of Contracts with Stable CPI	96%	92%	64%
	Based on CPI at 30% complete		
Percentage Interval	10.0%	7.5%	5.0%
Number of Contracts	25	25	25
Number of Contracts with Stable CPI	23	20	14
Percent of Contracts with Stable CPI	92%	80%	56%
	Based on CPI at 20% complete		
Percentage Interval	10.0%	7.5%	5.0%
Number of Contracts	25	25	25
Number of Contracts with Stable CPI	21	17	15
Percent of Contracts with Stable CPI	84%	68%	60%
	Based on CPI at 10% complete		
Percentage Interval	10.0%	7.5%	5.0%
Number of Contracts	25	25	25
Number of Contracts with Stable CPI	17	15	7
Percent of Contracts with Stable CPI	68%	60%	28%
	Based on CPI at 0% complete		
Percentage Interval	10.0%	7.5%	5.0%
Number of Contracts	19	19	19
Number of Contracts with Stable CPI	7	4	3
Percent of Contracts with Stable CPI	37%	21%	16%

The difference between the CPI range and interval results is attributed to the fact that the CPI interval is centered on a the CPI at the 50 percent point. When the CPI that is used to calculate the percentage interval is not exactly centered between the maximum and minimum CPI, a portion of the percentage interval becomes irrelevant. Had the CPI that was used to calculate the percentage interval been centered, the results of the two methods would have been more nearly equal.

Sensitivity to Final BAC. Clearly, the final BAC is not known until the final CPR is received. In practice, the percent complete computation must therefore be based on the most current CPR. To determine if the results were sensitive to the use of a current month percent complete, the CPI range and interval tests were re-accomplished using the BAC at the 50 percent point instead of the final BAC. As detailed in Tables IV and V, the results of the CPI range and interval tests were generally insensitive to the percent complete definition.

CONCLUSION

The hypothesis tested was that the CPI is stable after a contract 50 percent complete. CPI stability was defined in terms of CPI range (less than .20) and interval (+/- 10 percent) from the 50% completion point. Based on the performance data of 26 CPRs from 7 aircraft procurement programs extracted from the ASD cost library, the hypothesis was confirmed. The CPI range was stable from the 20 percent completion point. The CPI interval was stable from the 50 percent completion point.

Knowing that the CPI is stable is important. One reason is that the Government can now conclude with some confidence that a contractor is in serious trouble when overrunning the budget beyond the 50 percent complete point. Despite any optimistic claims of the contractor, it is extremely unlikely that a contractor will recover from a cumulative cost overrun after the contract is 50 percent complete, especially if the TCPI exceeds the CPI by more than 10 percent. In fact, results of the sensitivity analysis show that the CPI range is stable as early as the 20 percent complete point.

Of course, the generalizability of these results to other Services or programs are suspect, since the results are based on a database limited to only Air Force aircraft. Additional research using cost performance data on Army and Navy aircraft, and with other types of programs, such as avionics, engines, or missiles, is continuing at AFIT.

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TABLE IV

CPI RANGE STABILITY USING CURRENT MONTH BAC

Percent Complete	50%
Total Contracts	26
Contracts with Stable CPI	26
Percent Stable	100%
Maximum Range	0.093
Minimum Range	0.015
Mean Range	0.047
Standard Deviation	0.020

TABLE V

CPI INTERVAL USING CURRENT MONTH BAC

	Based on CPI at 50% complete		
Percentage Interval	10.0%	7.5%	5.0%
Number of Contracts	26	26	26
Number of Contracts with Stable CPI	26	25	20
Percent of Contracts with Stable CPI	100.0%	96%	77%

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INNOVATIVE PERT PROCESS

IN

ACQUISITION MANAGEMENT

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ABSTRACT

This paper describes a Modified Program Evaluation Review Technique (M-PERT) and Critical Path Methodology (CPM). These modified tools allow automatic manipulation of data and simply present planned actions and status for decision making. This methodology was used to manage a Request for Proposal (RFP) process. It used a combination of automated tools, human creativity and old fashioned thinking that allowed the Program Manager to use charts within the confines of a normal sized desk instead of an entire wall. The purpose of this paper is to show how a Program Manager's tools can be functional instead of decorative; simple instead of complex; ordered instead of chaotic. It shows how anyone with access to a personal computer, can employ this Modified PERT methodology without having first to become an expert in computer hardware and software.

This modified application of PERT is designed to: 1) allow the Program Manager to easily evaluate progress at any time; 2) provide a pictorial view of the interaction and delineation between events; 3) provide an in-depth perspective of the relational events and their impact upon the program; 4) serve as a reminder of the events to be considered for accomplishment while maintaining the flexibility to modify plans and successfully complete the project.

This paper discusses how various management curricula promote the use of automated systems (software) to design, develop and create PERT diagrams. It further describes how human factors associated with such software has not been fully considered in traditional PERT. For example, it is not necessary to create a PERT diagram that is sixty (60) feet long and four (4) feet high containing convoluted lines and boxes resembling an explosion in a string factory.

The described methodology encompasses five areas. They: 1) provide an opportunity for personnel to understand the "Program" in which they become a team member; 2) allow participants to identify and accept responsibility for accomplishments; 3) simplify PERT network creation; 4) allow network changes without losing the planned baseline; 5) identify only essential events to be accomplished while supplemental information is more appropriately presented as flexible reference material.

Basically, this paper emphasizes that people are the most important element in the planning and management processes; that all other things such as computers, software and paper are merely tools that help us reach intended goals.

INTRODUCTION

Background. Most of us who are familiar with the Program Evaluation Review Technique are aware of its origin with the Navy in 1957 for use with the Fleet Ballistic Missile program better known as the Polaris program.[1] Previously, the concepts of PERT were recognized at the onset of World War II in the area of logistics whereby extensive planning took place in order to effect timely delivery of people, equipment, supplies, munitions, food and a host of commodities with planned pipeline replacements. Thorough planning required consideration of the interactions between events and tasks performed by multiple agencies in parallel or linear modes. Since World War II planning techniques and the formalizing of PERT in 1957, there have been many changes incorporated into PERT.

The Critical Path Method initially related to the longest time to complete a program by combining all of the times allotted to each event and accounting for the relationship between all events. As programs became more complex and the availability of computers more common, other factors were incorporated into the PERT process. Some of these items include personnel resource allocation, personnel assignment by the hour and any fraction thereof, personnel assignment by labor category and cost rates, start and stop time to complete each task and/or event, predicted costs, allocations for contingencies and finally, optimization of the dollar expenditure and return on investment relative to allocated resources over time. Thus, contrary to the initial design and development of PERT as a technique, people were nearly lost in the process because the deluge of information provided by data processing became "the decision" instead of an aid to assist and support decision makers. In essence, we began to impede thinking and creativity as PERT diagrams became larger and more complex and eventually, in some cases, an unmanageable hinderance. During the 1970's, some business and engineering schools began looking for other tools with which to manage projects and were avoiding the use of PERT.

In response to this negative reaction, software companies tried to incorporate more flexibility into the PERT software in order to tell managers what they wanted to hear instead of depicting reality, opportunities for re-thinking and evolution in planning.

Managers want to hear that their project will be completed by a given date (a best guess) without being bothered by the details of a breakdown of the project into measurable events within modules. Consequently, what happened was that a completion date would be set; then all activities, tasks and events would be made to fit within this time frame. Further, to ensure the completion date did not change, a term called "negative slack" was developed. This meant that all delays encountered in the completion of assigned tasks were allocated to the next events to be completed, thus demanding allocation of more resources, usually necessitating longer work hours for an already over burdened staff. The process of using a fixed, (PERT) completion date became a no-win situation for the employees and ultimately a failure for the manager. This required a change in thinking whereby, if a task or event was not done in sequence as depicted on the PERT chart, the PERT "expert" manager blamed planners for scheduling events out of sequence. Thus, computer input was changed to redraw the PERT diagram with the incomplete events relocated down stream in the network diagram. The result was to produce a "perfect" network diagram by the time the project was completed. However, no thought was given to the valuable information to be derived by using the diagram as originally developed and maintaining a record of how progress was made. Once again, the manager was the ultimate loser.

It became evident that there were several forces working against successful accomplishment of PERT planning and program completion. To reiterate, some of these forces included the establishment of illogical, arbitrary project completion dates, the perception of failure by the employee, the PERT technique failure, and the conversion of "poor planning" to ultimately "perfect planning" with the manager still the loser. Bigger was perceived to be better and, in general, everyone had to have their "fingerprint" in the process of planning and the development of the tools. Unfortunately, these "fingerprints" were incorporated into computer software in an attempt to satisfy as many requirements as possible. As a result, software became more complex, diagrams became unmanageable due to their voluminous size, reports were used as decisions to determine who would do what and when, without deviation. Once again, the employee was involved with the manager in a lose-lose situation.

Objective. The objective is to briefly describe how a Modified PERT process can turn a lose-lose situation into an experience whereby both the employee and the manager can be winners.

Scope. In this paper, we will discuss how a combination of automated tools, human creativity and old fashioned thinking can produce PERT network diagrams useable within the confines of a normal sized desk instead of occupying an entire wall. We will discuss a change in the process and the thinking that goes into the development of PERT and CPM networks. Further, we will demonstrate how the prudent use of Total Quality Management (TQM) will allow employees to exercise their inherent motivation to become creative and, most importantly, committed to team work and timely program completion.

Concepts and Methodology. The concept is simplicity in its basic form. First, we must understand the system we are interested in, its modules, milestones, events, tasks or activities. Second, we must believe that people are self-motivated to be successful in their endeavors and can think and be creative without waiting for a computer output to provide calculated direction of when to start or stop an activity.

The methodology to be discussed will place more emphasis on people than on the computer. We will show a more realistic interaction between computer products and people's uses of them while eliminating the notion that the computer is the panacea for all our problems.

PERT DEVELOPMENT COMPLAINTS

Traditional PERT. The development of Modified PERT (M-PERT) came about as a result of practical experience coupled with several business management courses wherein the application of the traditional PERT and CPM was taught based on a single chapter in the text that was supposed to be all inclusive. In all courses, and there were four (4) different texts[2, 3, 4, 5], the instructors did not have practical application experience. Therefore, the students were led to believe that computers should be used with application software to draw and re-draw PERT networks, schedule each event down to the task or activity level desired, schedule all resources, and then let the Project Manager use the processed data as information which determines action to be taken instead of the data being an assist to decision makers. Human factors were never considered in these courses. For example, the size of PERT network diagrams was not a consideration. It seemed that the bigger, more complex a diagram could appear, the more impressive and believable it became. Nothing could have been further from the truth. We did not discuss the need for simplicity of a PERT network diagram designed to enhance communication and to allow ease of understanding by all involved so that they could identify and appreciate their personal contributions to the program. In fact, two of the instructors and several of the older, experienced students explained all the "problems" associated with the PERT and CPM tools. Actual experience by this author, with applied PERT and CPM in the work place, confirmed the negative attitudes towards the use of these tools.

Simplicity. As a result of hearing the negative attitudes towards the tools that ensured success with the Navy Polaris program, several problems were defined. For example, PERT networks resembled an explosion in a string factory. The diagrams were being designed with multiple boxes (events) being connected by multiple lines that crossed back and forth across other lines, sometimes reaching from the beginning of the diagram and terminating near the end of the diagram. Couple this type of network design, for a program that extends over a 24 month period, and display it on a chart that is 60 feet long and four (4) feet high, and you can begin to understand why the chart appears impressive but fails to quickly communicate what remains to be done.

Functionality. Further, re-arrange this diagram every month, because of events deferred for accomplishment at a later time, and then ask the employees and managers to quickly become re-oriented and understand the current program status. The result is frustration, lack of commitment to a purported schedule, buck and blame passing, and all the other elements that contribute to planned-in failure.

Manageability. PERT and CPM Network diagrams, according to many previous users, were not manageable. The resources required to maintain the diagrams and produce reports were expensive. Some software application programs could be purchased for $450 to $2,500. In addition, a computer may be dedicated to the process with both a printer and plotter for diagram production. A dedicated staff for management and input/output processing was also required. In addition, engineering management was tasked with filling-out extensive progress reports with data in a format and medium that required manual input into the computer. All of these resources became quite expensive in terms of salaries, capital investments, employee morale and program delays. Consistently, computer output products pointed directly to cost areas, managers, supervisors and employees that were delaying progress. This was a real lose-lose situation. PERT and CPM were unmanageable.

Useability. The example provided above is but a sample of several practical experiences observed over many years. Not only was the PERT and CPM process unmanageable, the results were also not useable. Neither a Chief Executive Officer, company President nor Vice President should have to view convoluted diagrams that serve as "wallpaper" around an entire room with the starting and ending points separated by a doorway. Anyone from the Chief Executive to a production worker should be able to understand how they, as team members fit into the entire scheme of the program, discern what the current progress status is and identify future efforts required.

M-PERT DEVELOPMENT CONCEPT

Management Tool. One requisite for development of the M-PERT concept was to ensure the resultant technique is manageable as a working tool. In order to fulfill this requisite, the M-PERT and CPM network diagram must contain only meaningful information to be communicated to the user. Further, maintenance of the network should not consume an inordinate amount of time by either the individuals providing input data nor those charged with data processing, analysis of information and report preparation.

Simplicity in Design. A second development requisite was simplicity of design. This meant that diagrams should provide only that information required at a particular level of management. For example, a top level chart might depict 30 milestones with specific calculated dates for completion. A lower level diagram may then be prepared, let's say, for software development, another for hardware development, and others for hardware/software integration and 1st, 2nd and 3rd article testing. By following progress on these charts, the top level diagram can easily be updated.

Design Rules. There are five simple rules to follow in the development of an M-PERT diagram.

<u>Rule 1:</u> Look at the diagram development as "Results Oriented". The diagram should indicate completion only and not contain blocks depicting when a task or event should be started. To reiterate, each event block should indicate when the event will be or has been completed. The line entering the event block from the left, represents the time remaining after completion of preceding tasks. The **<u>time remaining</u>** to complete the next event after task completion of the preceding event, is placed on this line. (See Figure 1).

The beginning of the time interval remaining is measured from the completion of a previous event to the completion of the next related event. This remaining time between events is the relationship between event completion dates and has no relationship as to when events must be started. This notion is the crux of the M-PERT methodology whereby M-PERT allows the manager to focus on when "results" can be expected.

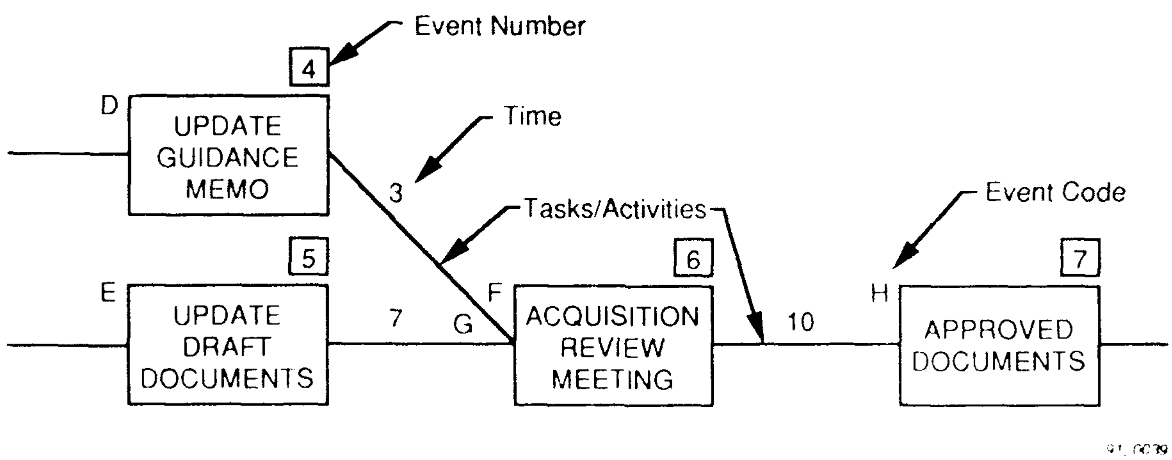

Figure 1

This time can be represented in hours, days or weeks. In order to convey understanding of what task or activities are required to complete an event, prepare a Program Manager's Handbook that contains Event Codes (e.g. D, E, F, etc.) followed by a listing of all the activities associated with that event. This Handbook will also be used by project team members to estimate the points in time when they will commence their individual or team efforts in order to complete the task as scheduled.

Management styles have evolved over the years from when professional employees were told when to start their effort and when it should be completed. Later, we began to show trust in employees by asking when they think they may complete a task or event, agree on the time frame and then monitor progress and offer help, if necessary. Gone should be the days when, on May 1st, an employee states he/she can complete an event by 16 May and then the manager asks every day thereafter, "Have you started yet?". However, a manager can act as a facilitator and follow-up on 8 or 10 May to see if there are problems to be resolved. Allowing employees to see the project or program as an integrated network with M-PERT, they can better appreciate how they will be involved and interact with other team members. These team members must also understand their responsibility to begin their efforts in time prior to the completion of the previous two or three events, dependent upon the magnitude of the overall effort required. Using this management style tends to encourage the professional employee at all levels to become committed to completing their own efforts in a timely manner, thus positively contributing to the total project.

<u>Rule 2:</u> Activity or task lines will not cross another line. There are many different ways to complete a project with multiple activities or tasks involved. Each designer will develop a different M-PERT and CPM network design. Thus, there is no absolute design. With a little re-thinking, events can be arranged without crossing lines. This effort is made simpler by not having a block depicting when an activity will "START" and another block showing when an activity has been "COMPLETED". Remember, this is a "results oriented" management tool. If you, as a network designer, are unable to avoid crossing lines, allow someone else to redesign that portion with which you are having trouble. Many times, the order of completion of events within a group does not make any difference, which brings us to our next rule.

<u>Rule 3:</u> Develop the The M-PERT and CPM network diagram as a road map. For example, if you plan a vacation and outline your route, only to find during the trip that there is a detour due to highway construction, you do not send your map back to the cartographers to be redrawn. Instead, you may make a note in your travel log as a reminder (lesson learned) before planning your next trip. The same applies to the M-PERT network diagram. If you do not have the resources to complete Event D before Event E (See Figure 1) perhaps completion of Event D may be deferred until later in the program. This differs from other applications software which require that each event be completed in the order in which they appear on the diagram. This type of software does not consider the Program Manager's situation and further requires that the "road map" be redrawn in order to be accurate. Perhaps a particular event was inadvertently scheduled out of sequence. If the diagram is redrawn, the physical picture changes from the familiar to the unfamiliar since relationships are changed. Using the M-PERT methodology, a notation is made in the Program Manager's Handbook listing the reason for a future change and lesson learned. The next time an M-PERT and CPM network is drawn, the Program Manager can improve the planning process by taking advantage of the previous "lessons learned".

Rule 4: Use color coding to indicate the status of progress relative to the network diagram. For example, if an event is complete, use a color like green to show completion. If half of the remaining time to complete an event has been consumed, then use green for only half of the event block. If the event has only been started, so indicate by using green in one corner of the event block.

If an event will be intentionally bypassed due to changing requirements, use another color, such as yellow, to indicate that a conscious decision has been made and acknowledged by the Program Manager not to complete the particular event. In this case, the remaining activity time will be reduced to zero.

If an event is not accomplished but **must** be completed sometime in the future, do not color the block nor remove any time from the network time calculation. Consequently, each time progress on the diagram is evaluated, the incomplete event will always show up on the Critical Path no matter how much has been accomplished out of sequence. In this case, both the computer CPM listing and the pictorial display serve as two methods for reminding the Program Manager of an impending problem that must be addressed.

Rule 5: Draw your network diagram by hand and out in the open where you can see the whole system and its interrelated processes. Do not become overly concerned with drawing an M-PERT and CPM network diagram with a computer. Most computer software applications provide the capability to create network diagrams at the personal computer keyboard. The results of this type of network design does not allow the designer the capability to develop a network diagram from a systems point of view. Instead, the design is created based on what is readily visible on the screen. In other words the trite phrase "Out of sight, out of mind" is appropriate. In addition, it becomes impossible to comply with all the rules discussed above. As a result of violating these rules, countless problems are built-in to the process and defeats the original purpose of PERT. Some of these problems include hiding work-arounds, hiding lessons learned, and obfuscating the pictorial presentation of the roadmap, only to mention a few. This type of design encourages changes thus never establishing a baseline. Remember, computer products are designed to "assist" and "support" decision makers. However, many times, managers will ignore an M-PERT diagram that was created as a total entity simply because it was not produced by a computer. In other words, some of these managers are aware that the process of "wordsmithing" or making quick non-substantive changes on a computer is necessary in order to portray a more "perfect" plan, thereby hiding what they perceive as defects. M-PERT and CPM, like any other PERT, is designed as an assist to the user for program evaluation and not intended to be used as a "whip" for personnel evaluation. There are many other management tools available for personnel evaluation that are quite effective. The M-PERT and CPM method is designed to take advantage of each person's inherent motivation and self-discipline (associated with "super-ego" and "id") leading to concrete accomplishments and success.

M-PERT and CPM application. While attending a seminar on the application of commercially prepared PERT software, costing between $800 and $1200, the vendor responded to a question stating that their most advanced PERT software customers use less than 40% of the software capability. The reason for this under utilization was due to the training required to learn how to use the software and then the personnel effort required to produce all the products. It was further estimated that an average of only 25% of the software package was used across various industries. This particular vendor was rated as one of the leaders of PERT-CPM applications programs.

M-PERT and CPM uses a BASIC program that was published and made available in bookstores across the nation.[6,7] One of these programs was pro-rated to cost 33 cents[7] and yet was used to calculate the M-PERT Critical Path for an Emergency Communications Network with a cost in excess of $145 million. Further, this program was being run on a Radio Shack Color Computer with 16K memory. The output from this application was used to measure the prime contractor's progress. Meanwhile, this same contractor displayed a 60 foot PERT diagram and used a dedicated IBM mini-computer with three (3) permanently assigned employees for monitoring, processing and reporting program status. There can be no doubt which methodology produced the best return on investment.

M-PERT and CPM has been used to manage several Request For Proposal (RFP) preparation processes[8], Full Scale Development, and Demonstration/ Validation type programs. In addition, it has been used to plan and relocate a State run computer center and the entire support staff. The M-PERT methodology has also been used to clarify processes outlined in various acquisition directives to include Cost and Operational Effectiveness Analyses with related activities required for presentation to the Defense Acquisition Board.

Functionality of M-PERT. The basic concept of establishing a baseline, depicting the baseline on paper and then making it accessible to all the users, helps to promote communication among all the team members. Further, the network diagram, or "road map" can be used as a note pad whereby suspense dates for completion of particular events may be penciled directly onto the drawing. The name or names of team members may be annotated immediately beneath an event for which the member accepts responsibility. Color coding of events relative to completion is another feature that enhances the communications capability of the M-PERT diagram. In addition, the diagram is small enough to be placed on a normal sized desk. It can also be folded and normally placed into a three ring binder or more easely displayed in selected key areas where team members tend to meet.

Manageability of M-PERT. The time increments allocated to the completion of a task after a previous event has been completed, should be measured in days or weeks not to exceed 30 days or four (4) weeks. This is especially true if the network diagram is developed for the operational level. Normally, when time increments exceed these limits, it is a good indication that the associated events have not been reduced to a manageable nor reasonably measurable size. Therefore, further design consideration is appropriate.

Data Collection. Data collection is one of the most important elements towards maintaining reliable information on progress within the project. It is also essential that data collection be a scheduled activity whereby functional area representatives meet to report progress on assigned events. The person collecting the data need only be familiar with project scheduling to be able to carry on a question and answer dialogue with the functional area representatives. The meetings should be short and to the point.

Data Processing. Two of the references in the Bibliography (items 6 and 7), contain BASIC programs that, once installed on a personal computer, can be run by clerical personnel.

Data Analysis and Reporting. As soon as the data has been processed, the knowledgeable scheduling person must again become immediately involved, analyze the output data and formally report the findings to the Program Manager. It is also equally important that all findings included in the report be confined to facts. The results obtained from processing data will provide the factual derived information necessary to support any decisions to be made by the Program Manager. Further, certain problems will become apparent as a result of the data displayed. This will allow the experienced scheduler to formulate recommendations for consideration by the Program Manager.

Flexibility of M-PERT. The Program Manager's Handbook, which was mentioned earlier, allows the Program Manager to add additional activities to an already identified event. If more time is then required to complete the associated event, this data is provided to the scheduler for incorporation into the next processing cycle. If an event is to be bypassed intentionally, then the associated completion time may be deleted without changing the appearance of the diagram. If either of the two BASIC programs mentioned above are used, they will not abort the calculation process for lack of information. Nor will there be a requirement to re-arrange the diagram into a different sequence to accommodate the change in the baseline plan. By going back to "basics" literally, the Program Manager can retain control of the total program effort.

CONCLUSION

M-PERT and CPM requires a re-thinking and change to mental processes employed with traditional PERT. Traditional PERT requires clear definition and portrayal of when events are scheduled to start and end. M-PERT on the other hand, requires systemic mental processes whereby events are viewed as being interactive with portrayal of "results" exclusive of event start times. M-PERT results in making changes to the process without changing the individuals. In order to reach this goal, certain accomplishments were recognized such as using M-PERT and CPM as an available tool, transportable to the customer instead of transporting the customer to the tool. Another benefit was the increase in functionality through simplicity in design. This incorporates one of the precepts of Total Quality Management which better recognizes and utilizes the inherent capabilities of employees. In addition, once the baseline network has been developed and approved, only part-time clerical support is required for computer processing with a Program Management level of support required for detailed analysis, evaluation and reporting. Small projects of $5 million or others such as the RFP process requires no more than four (4) hours of effort each week to complete the data collection, computer processing and reporting functions. Further, no one has to become a computer guru. Instead, the computer can be used by a novice to calculate a deterministic or probabilistic Critical Path. In this way, the computer is a simple and functional tool for program project management.

The baseline M-PERT and CPM network diagram can be utilized at the outset as a pictorial project "road map" and at project completion, the lessons learned can be easily determined because they have not been hidden.

As for flexibility, M-PERT and CPM are most flexible. For example, when setting-up and designing the network, all possible events that are considered applicable, may be incorporated into the diagram. This is done in much the same way as wickets are set up for a game of croquet. However, should the players decide not to use a particular wicket, it can be consciously by-passed, and, in the same way, an event may be bypassed. The advantage to using the M-PERT methodology is that an inanimate computer will not halt the update process when the Program Manager decides to change strategies or accomplish events out of design sequence. Instead, the results of the M-PERT process serve to constantly remind the Program Manager where attention is required.

Another advantage is that delays in the project schedule are not discussed as negative slack time, thereby giving the false impression that all that is required is to throw personnel resources at the problem for resolution. The M-PERT process allows the Program Manager to be pro-active and anticipate future requirements and opportunities for replanning without losing sight of the original plan, its intent and goal.

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CALS: NEW SOLUTIONS TO OLD PROBLEMS

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ABSTRACT

In complex organizations there is a traditional three step approach to problem solving: building a conceptual model of the problem, translating the model into policy, and evolving the policy into planning and management action. Key to the success of this process is correctly building the conceptual model. If the model is incorrect, then the translation to policy and management action will have a very low probability of success. (1)

In the case of two major Department of Defense initiatives, Computer-aided Acquisition and Logistics Support (CALS) and Electronic Data Interchange (EDI), policy-makers have built a conceptual model within which to plan. The first step included the development of industry, national, and international standards to define the means and media for digital data interchange. The second step, that which is being implemented now, is to use an evolutionary method based on pilot program offices to contractually implement these standards through the use of a service called the Contractor Integrated Technical Information Service (CITIS) in all new weapons systems contracts.

This paper challenges a basic assumption used in building the original conceptual model that the program office is the proper unit for implementing change. The program office, in actuality, is a matrix of functional disciplines which have best operated with a high degree of autonomy. The government and industrial infrastructures have formed around these functional "stovepipe" suborganizations linking them physically and culturally.

While the stated intent of CALS/EDI planners was to follow an evolutionary approach, the use of pilot program offices is actually "revolutionary" in nature because the single program office cuts across all functional disciplines; that is, nearly every function is altered for that particular office. The government and industrial infrastructures cannot be used to adequately support the goals and objectives of the program. Such a revolutionary change, even if the revolution is unintended, does not have a high probability of success.

This suggests that an alternate approach focusing on the functional disciplines within the program office as the basic unit for change may have a higher probability for success for a number of reasons. First, changing one function can be managed within the program office and within the supporting infrastructure. Second, since functions are common, other program offices can become involved in the change to CALS/EDI and gain experience applicable to other function. The functional discipline associated with the Cost/Schedule Control System Criteria, is useful as a conceptual model in developing a "lead" function for achieving effective organizational change. Other functional disciplines, the "lag" or follower functions can be planned for follow-on implementation taking into account lessons-learned during the process.

BACKGROUND

The Department of Defense has entered into a second phase in the implementation of two wide-ranging initiatives to modernize both defense manufacturing and weapons system acquisition. These initiatives are based on the increasing use of standards which are compliant with Computer-aided Acquisition and Logistics Support (CALS) and Electronic Data Interchange (EDI). Part of this new phase includes the development of a specification for a Contractor Integrated Technical Information Service (CITIS). The CITIS is defined in a draft specification currently under review by the Office of the Secretary of Defense (OSD) as a "contractor provided, computer-based service that provides the government with access to program (i.e. business and technical) data and applications associated with system acquisition." (2)

The overall intent of the CITIS specification is to define the process which allows access to all data relevant to the design, manufacture, deployment, and life cycle support of a modern weapons system. This service makes it possible for acquisition managers to view and process data, whether originated by the prime contractor, sub-contractors, or the government, as an integrated system even through the data source itself may not be integrated into a single database host. The integration mechanism is meant to be transparent to the government user and can include user applications necessary for the manipulation of data and the storage of resultant information.

I had the opportunity to observe some of those most responsible for the development of the CITIS specification during various meetings of the Technical Advisory Group and two CALS workshops. Like many such dedicated professionals, they had the tendency to "boldly go where no one has ever gone before". As the discussions continued it became clear that the use of computer-aided technologies is a very powerful means for conducting weapons systems acquisition and will become more important as the technology advances. However, there is a biase to emphasize the technology, perhaps out of its proper proportion in the weapons acquisition process and treat the acquisition of this service and the attendant hardware and software as an end in itself.

The end product in weapons systems management is the ship, plane, tank or other system needed to promote the national defense. Systems and equipment must be effective and reliable, acquired on-time, and at a fair price to both the contractor and the government. CALS, EDI, and now the CITIS are possible new tools, but the objectives associated with weapons systems management remain the same.

An overemphasis on the technology has caused a certain amount of skepticism from program management personnel who have expressed the opinion that DoD policy makers have lost perspective. In a Technical Managers Advanced Workshop conducted at the Defense Systems Management College from 25-29 June 1990, senior official from both government and industry reviewed the status of implementation from a program office perspective. They made a series of conclusions and recommendation to the OSD CALS/EDI Office. It was their considered judgement that successful implementation is inhibited by misunderstandings and misconceptions about these initiatives and the lack of an integrated management approach to them.

Contained in the report from this

Workshop are recommendations to overcome what they perceived to be major inhibitors. There are three recommendations which had the highest priority and which can be addressed together. They are:

> "DoD must be more specific in defining CALS objectives, delineating responsibility, with each service ensuring CALS within established infrastructure."
>
> "Try to attack the problem in smaller pieces rather than one big global approach."
>
> "Clarify by example: create, maintain, and communicate a simple catalog of practical CALS benefits segregated by beneficiary groups and end users (e.g., fleet, program managers, vendors, sub-contractors, prime contractor...etc.)(3)

The purpose of this paper is to provide an option for implementation which follows from the recommendations provided by the workshop participants. This approach is threefold. The first objective is to explore the similarities between the Cost/Schedule Control System (CSCS) Criteria and the requirements for the CITIS as described by the draft CITIS specification dated 31 December 1990. The second is to make a case for the implementation of CITIS requirements through the expansion of the existing procedures and infrastructure associated with the use of CSCS criteria. And the third is to define the benefits and consequences of using this more "evolutionary" approach to the broader goals linked to the implementation of CALS and EDI.

SIMILARITIES BETWEEN CITIS AND CSCS

The CSCS criteria concept grew from an initiative by the Air Force Systems Command to devise a uniform method of cost and schedule control and reporting throughout the Air Force. The method which the Air Force eventually created depended on a standard report in a standard format called the Cost Performance Report (CPR). However, a report is not effective if there is no easy and accurate procedure to verify the numbers on the report.(4)

In the case of the CPR, the source data are imbedded in the cost and schedule systems of each contractor. Requiring a standard system for all government contractors was impractical, so the Air Force developed a set of criteria which defined a "compliant" cost and schedule control system. Through a series of reviews described in an implementation guide, government personnel inspect the contractor's internal organization, procedures, and policies. Changes to contractor systems are required only to the extent that existing features do not meet the minimum requirement.(5)

Once the contractor can demonstrate that the firm's internal cost and schedule control system meets all of the criteria, the government certifies that the contractor is fully compliant. This is generally a DoD-wide certification and applies to all major contracts regardless of the initiating agency. Data from compliant systems is the basis for monitoring cost and schedule control data for all government purposes. The contractor's system requires no additional inspection or review unless significant changes are made to the overall procedures.

The Air Force system became the basis for DoD Instruction 7000.2 entitled, "Performance Measurement for Selected Acquisition" in December, 1967 which is now the basis for cost and schedule monitoring throughout DoD. In 1984 the Assistant Secretary of Defense (Comptroller) commissioned a study by Arthur D. Little, Inc. to assess the level of acceptance of the CSCS criteria by both defense contractors and government program managers. The survey highlighted areas for improvement in the use of the Criteria, but the most important overall conclusion reached by the researchers was that it is "a valid" concept and approach to controlling contract performance."(6)

Similarly, the CITIS specification is designed "to define the government's baseline functional requirements for integrated technical information services that can be tailored for all acquisition programs."(7) It is acknowledged in an accompanying white paper that each contractor will have its own set of hardware, software, and sets of business relationships with sub-contractors and vendors which make its internal information system unique. Many of the data bases are autonomous such that the integration required by the CITIS is only apparent and not actual.

In many cases the "specification" does not contain precise instruction as might be associated with other military specifications. For example, under the requirements statement for CALS implementation planning, the CITIS specification demands that, "The contractor shall conduct all planning necessary to ensure that CITIS is properly implemented."(8) It provides no additional instruction as to how "necessary planning" is to be defined. Other sections are similarly vague. Where specific guidance is provided, specific direction is usually in reference to other specification and standards such as MIL-STD-1840 and ANSI X12.

This is not a criticism of those responsible for writing the CITIS specification, but it recognizes the difficulty inherent in trying to define the service in even general terms. CITIS does not lend itself to exact definition. Rather than characterizing this document as a "specification" in the traditional sense, it is in reality more a statement of general criteria. It does have a close relationship to the procedures which were used in developing the Cost and Schedule Control Systems Criteria developed in the 1960's and are still in use today. As stated in the "Cost/Schedule Control Systems Criteria Joint Implementation Guide" the governments objective to not to describe a specific system:

> "C/SCSC is not a system! It is a set of criteria designed to define an adequate contractor cost and schedule management control system."(9)

CITIS and C/SCSC have different objectives, even though one use of CITIS is the same as the C/SCSC, that is, montoring contractor performance. CITIS goes beyond that single function and has implications through the life-cycle of a weapons system. The relevance of the Criteria to the Service is in the requirements or process definition, and in qualifying the process through which the actual monitoring services are provided.

THE CASE TO IMPLEMENT CITIS THROUGH CSCS MODEL

Recognizing the similarities between the CITIS concept and the CSCS criteria provides clarity and definition but most of all it provides a familiar, and user friendly, model to follow. Such a comparison also lays the groundwork for gaining acceptance by both government and industry program management offices which already understand and use the CSCS process and may resist change to what would be perceived to be a more complex and complicated system. Of course, the comparison is not an exact match and there are areas in which the two concepts diverge. But even when the two deviate, it is easier to explain the deviation from a known CSCS position. The following five areas are of special note:

1. Using a criteria rather than a specification for CITIS.

Each contractor has a series of well-defined design, financial, and logistics systems which evolved over time. Each system has a different logic and set of definitions which are a part of the unique operating environment of the enterprise based on its technological and industrial base. It is easier to develop a set of criteria which allows each contractor to function within its unique environment than to develop a set of specifications.

2. Implementation by expansion.

The Cost/Schedule Control System Criteria provide a model for sharing information which is retained within the contractor's system but monitoried at a report level by the government. If this model is effective, as the Arthur D. Little Study suggests, then the same concept of operation may be applicable to other functions, even though the functions do not directly relate to one another. "Implementation by Expansion" in this context does not imply expanding the cost and schedule control system to include all the data that a program office may require for life-cycle support, but to use the same concept of operation and apply it to other functions inherent in the weapons systems acquisition process.

The Cost/Schedule Control System Criteria, besides providing the model, can also be the first set of criteria which can be a part of the service defined by CITIS. Additional functional criteria can be added based upon key knowledge areas required for program management. For example, the 1991 Application guide for the Malcolm Baldridge National Quality Award list "Key Concepts in the Award Examination Criteria". The Defense Logistics Agency has used these criteria to develop an on-going In-plant Quality Evaluation program based on the same criteria.

Other functional knowledge areas important in program management have been defined as follows:

Systems Engineering
Logistics
Manufacturing/Production
Software Management
Test and Evaluation
Cost Estimating and Funds Mgmt
Contract Management
Contract Finance
Acquisition Policy and Org
Management Control(10)

3. Development of a CITIS infrastructure within current governmant offices.

The CITIS specification as written assumes that the requiring office has the necessary information systems specialists to tailor the provisions of the specification to the minimum needs of the program and that the contractor administration office has the expertise necessary to monitor compliance. Generally, program offices and contract administration offices are staffed with specialists in the technical, logistics, and business specialties necessary to acquire the end item. To the extent that information systems expertise is required to support the acquisition of the end item, the assumption may be true; however, in the majority of program offices such expertise will not exist.

Since the expertise to fully implement CITIS through the specification approach is not routinely available in program offices and contract administration offices, the question arises as to how the expertise can be acquired. The program office might acquire such expertise through contracted support services. However, this could create additional problems for two reasons: first, funds for contracted services are severely limited and the expansion of such services is discouraged by current policy. Second, contractors are already warey of allowing government access to data bases and the possibility of access by a third party on behalf of the government could only add to the current reluctance of major contractors to participate.

While the expertise may not be resident in the program office or contract administration office, there is an existing government infrastructure to support CSCS compliance and assist program offices in the use of the information received from compliant systems. Contract administration offices have a great deal of familiarity with monitoring the cost/schedule control process and the Cost Performance Reports. This familiarity is adaptable to the expanded CITIS. This existing infrastructure would need substantial expansion and modernization to support CITIS. However, expanding the role of existing government offices gives implementors guidelines to determine what additional resources may be required. Perhaps even more important is that existing planning and budgeting methods can be used to request additional operations and maintenance (O&M) funds to support modernization.

4. Use of Compliance Reviews.

In the CSCS concept of operation the government requires a "compliant" system as defined by the Cost/Schedule Control Systems Critieria Joint Implementation Guide. To establish this, the procuring activity conducts a highly structured series of visits, assessments, and reviews with assistance and direction from the CSCS focal points within the military service component which supports the procuring activity.(11) After review, the service focal point issues a tri-service certification which makes the contractor's system acceptable for all DoD contracts which require compliance. Subsequent reviews can be scheduled when the contractor makes significant changes to the system or upon award of major contracts.

The use of compliance reviews in the manner of the CSCS model takes the pressure off the individual program office to judge the effectiveness of the firms information system. Once the reviews are complete, the program office and the contract administration office need only be concerned with the output of the contractor's system. The contractor also benefits because the contractors existing system need be changed only to the extent that it does not comply with the criteria and because once the internal system is found to be compliant, the contractor is not subject to additional complete reviews unless the system is changed.

5. Contractual Implementation.

The CITIS specification contains some instruction on procedures needed to describe the requirement for contractual purposes. Although the government has considerable expertise in describing complex requirement in a statement of work, the problems with the CITIS have defied simple explanation. One major problem is that the program office cannot adequately define the government's service requirement without some knowledge of the contractor's capabilities. However, at the time the requirement must be defined, the identity of the successful contractor is not known. The Cost/Schedule Control System Criteria are placed on contract through the use of a contract clause without any contract line item identification or detailed statement of work.(12) The program office is relieved of the burden of providing an exact definition because the requirement vehicle is a contract clause which states that the contractor establish, maintain and use a compliant system in accordance with the Joint Implementation Guide. The Guide then contains the necessary criteria and the procedures for certification.

THE ADVANTAGE IN REACHING CITIS THROUGH EVOLUTION

The study of change in organizations has been the object of management research for decades and the precepts of this research is part of any management course. The study of large-scale organizational change, such as that which could occur with the introduction of CALS and EDI into the Department of Defense, is a more recent development. Preliminary research indicates that large scale organizational change can be managed in a number of ways depending on the type of change, the time available to make change, and the urgency of the change. In general terms, changes which involve full-scale adoption in a large organization in a very short length of time, and are related to the survival of the enterprise, are the highest risk changes and those which have the opposite characteristics have the lowest risk and the best possibility for success. It is also clear that the way which management classifies the need and plans the change also has an impact on the rate of success.(13)

There is no single way to perceive the need for change. Two managers may see an event in the environment and react differently in terms of the need for change and the characterization of need. One may see the event as the beginning of a trend for which the enterprise may make an anticipatory change. The second may see the event as the evidence of a current condition and make an immediate reactive change.

The OSD CALS/EDI Office chose an experimental approach to large scale change based on the use of pilot programs. The effect of this type of implementation is that it requires a full-scale change in some program offices. It is clear from the workshop participations and from other sources that this approach suffers two major weaknesses. First, major change cannot be supported by the existing information infrastructure and pilot programs do not have the resources to finance the infrastructure modernization that would be necessary to fully comply with CALS and EDI. Second, program offices act with a great deal of autonomy based on unique weapons systems characteristics. It has been difficult to pass information between program offices relative to CALS and EDI implementation because lessons learned in one program are not viewed as completely relevant to any other program office.

A relatively simple variation on the pilot program approach chosen by OSD would enhance the probability for a successful and efficient introduction of CALS and EDI into weapon systems acquisition. The approach recommended here is called a "lead-lag" approach and consists of two basic premises. First, changes in the corporate culture, as is envisioned in CALS and EDI, cuts across all the functional areas of the enterprise. Therefore, the process is complex, expensive, and almost impossible to effectively control. A more sensible approach is to change one functional discipline at a time and manage that change closely. The second premise is that the chosen "lead" functional implementation can be reviewed by other, i.e., "lag" functional disciplines for "lessons learned" before the follow-on functions are scheduled for change.(14)

The "lead-lag" approach is not feasible in all organizational situations. It is most effective in organizations which have highly structured functional disciplines such that a change in one will not throw the entire organization out-of-balance. It is most effective in mature organizations which cannot be expected to change all of its functional parts at the same time without creating a sense of chaos. The organization Department of Defense and the major defense contractors which would have to create partnerships for CITIS and EDI are those types of organizations in which "lead-lag" has the highest probability of success. By using the CSCS criteria and implementation as a lead CALS/EDI functional implementation strategy the following benefits could be realized:

> Time: CALS has always been presented as an evolutionary not a revolutionary approach to weapons systems acquisition but within a participating program office it is a large-scale, revolutionary change. Making the cost control the lead implementation function allows all program offices to be a part of the implementation process at a pace which each can maintain.

> Scope: Each program office must deal with the change in technology related to the industrial base and commodity which it is acquiring. The lead-lag approach allows manageability of the acquisition process as separate from the weapons system technology.

> Leverage: Lead functional programs can be advertized as a program from which others are expected to learn. It is therefore important that the lead program be relevant to all program offices and that the probability of success is very high. The CSCS fits these objectives.

> Manageability: The CSCS function already has an infrastructure which can be used to assist in the implementation. Contract management commands already have the personnel necessary to conduct surveillance during the production process.

> Identifiable Beneficiary: The CSCS function already has an identifiable constituency which includes elements at all levels of the government and contractor organization. Success in this area can be communicated both horizontally (from program office to program office) and vertically.

In summary, recommendation which flows from this discussion is that the Contractor Integrated Technical Information Service can be more effectively implemented using the same basic structure that was used by the Air Force to implement the Cost/Schedule Control Systems (CSCS) criteria and that the CSCS criteria become the first functional part of the CITIS.
This approach addresses the concerns of government and industry program managers in that it is defined in smaller pieces, executable within the established infrastructure, and has an identifiable beneficiary group within the current program office environment. Other developments, including the use of a criteria approach to monitoring quality by the Defense Logistics Agency indicate that type of expansion recommended here does have further application in other functional areas.

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CAN SOURCE SELECTION BENEFIT FROM DECISION ANALYSIS?

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ABSTRACT

This paper investigates the efficacy of applying formal decision analysis methods to the selection of the "best" contractor for defense systems acquisition. First, we discuss decision analysis in general. Next, two particular decision analysis methodologies are reviewed: Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process (AHP). Their potential application to Air Force source selection is discussed. We next summarize previous research regarding the application of decision analysis methodologies to source selection. We conclude the Air Force source selection process can benefit from the application of decision analysis and suggest directions for further research.

1. INTRODUCTION

The sole objective of the source selection process for defense systems acquisition is to choose the "best" system. Simply stated, the intention is to make the "best" decision regarding which contractor should get the award. How does the United States Air Force go about making these important decisions? Do current regulations and directives provide a framework for thorough analysis of the proposals submitted for consideration? Can the process be improved? Has the source selection community taken advantage of the half century of research into decision making? How does the current decision making process compare to normative theories developed during this period? The purpose of this paper is to address these questions.

In the next section, we first discuss the fundamental ideas underlying decision analysis, followed by introductions of two important and widely used decision analysis methodologies: Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process (AHP). We then explain how MAUT and AHP might be incorporated in the Air Force source selection process and include what we believe to be advantages and disadvantages of adopting these methods. Finally, we summarize previous research into this topic and suggest directions for further reseach.

We limit our discussion to the Air Force source selection process as described in the current Federal Acquisition Regulations, and Air Force Regulation 70-15. We assume at the outset the reader is familiar with the Air Force source selection procedures.

2. DECISION ANALYSIS

"Good" decision making is the very essence of "good" management. However, "good" decision making is not easy because of the complexity inherent in problems confronting today's managers. The are several sources of complexity for decisions:

1. Uncertainty regarding the future consequences of one's actions.

2. Decision "quality" is determined by multiple, often conflicting criteria.

3. There are often multiple decision makers with conflicting opinions about the relative importance of the multiple criteria.

4. There is too little or too much information available regarding the decision problem at hand.

5. The impact of the decision is far reaching and involves substantial commitment of resources.

6. The impact of the decision will be felt far into the future.

7. The technological, economic, and political environments are characterized by rapid change.

Do we innately make "good" decisions when confronted with complex problems? Can we rely on intuition, on a holistic approach to make "good" source selection decisions? Can we somehow perceive, comprehend, and effectively consider all information relevant for complex decisions? Can we, by intuition alone, simultaneously evaluate each decision alternative and select the "best" one? The last half century of research into human decision making suggests not. Much has been written about our *inability* to effectively consider the important information available to us in complex decision scenarios, and how our intuition fools us, especially when uncertainty is involved. (c.f. Kahneman, et al, 1982). Research has identified and illustrated the need for "aids" to improve our innate, intuitive decision making faculties.

Decision analysis is intended to *assist* the decision maker in analyzing the problem in a logical, consistent, and rational way. To quote, Keeney (1982):

> *Decision analysis is the formalization of common sense for decision problems which are too complex for informal use of common sense. (p. 806)*

Not all problems should be subjected to decision analysis, however. Baird (1989) has suggested that decision situations should possess the following characteristics for decision analysis to be worthwhile:

> *1. They must be important.*
>
> *2. They are probably unique.*
>
> *3. They allow some time for study,*
>
> *4. They are complex.*
>
> *5. They involve uncertainty. (p. 6)*

Research into decision making can generally be classified as either descriptive or normative. Descriptive decision analysis is the way decision makers *actually* make decisions, whereas normative decision analysis is the way decision makers *should* make decisions according to some prescribed theory. Descriptive research (Kahneman, Slovic & Tversky, 1982, and von Winterfeldt and Edwards, 1986) shows decision makers almost invariably violate the normative approaches to decision making. These two fields of research are not necessarily mutually exclusive. A normative theory should be based upon an axiomatic foundation that is descriptive of the way humans actually think about decisions. The objective of normative decision analysis is, as Keeney (1989) states, to help decision makers make more informed and better decisions.

Decision analysis traditionally involves the decision maker(s) (and delegated experts) and decision analyst(s). The decision maker is the expert in the decision domain, whereas the decision analyst is an elicitor, formulator, and evaluator of information, preferences and judgements.

There are several popular misconceptions about decision analysis. It is not a replacement for the decision maker; it is not simply a "decision tree;" it is not a computerized "black box;" it is not a rigid approach that provides the de facto, "optimal" solution. Instead, decision analysis is a process with the purpose of *helping* the decision maker make "better" decisions. Decision analysis provides the necessary framework for making *consistent, logical, communicable and defensible decisions.* Decision analysis provides a framework for organizing and structuring a complex problem. Decision analysis provides a framework for the meaningful and efficient use of relevant information. Decision analysis focuses the attention of the decision maker on the important (*as determined by the decision maker*) aspects of the problem. Howard (1988a) summarizes decision analysis as:

> *A systematic procedure for transforming opaque decision problems into transparent decision problems by a sequence of transparent steps. Opaque means "hard to understand, solve, or explain; not simple, clear, or lucid." Transparent means "readily understood, clear, obvious." In other words, decision analysis offers the possibility to a decision maker of replacing confusion by clear insight into a desired course of action. (p. 680)*

Decision analysis employs a "divide and conquer" approach. It first decomposes the decision problem into its component parts:

1. alternatives: choices or possible courses of action
2. outcomes: possible consequences of a particular choice
3. likelihoods: probablity an outcome will occur.
4. criteria: the basis by which the quality of the decision will be judged.

Decomposition allows the decision to be broken into manageable pieces to facilitate understanding, insight and focused analysis. Such analysis forces the decision maker to consider very carefully and precisely the important components of the problem and how they are related. Such an analysis fosters clear conceptual understanding of the complex problem. It provides a *verifiable, reproducible, communicable and defensible approach* to decision making.

Once the problem has been clearly defined, the decision analyst elicits opinions and judgements from the decision maker regarding preferences for outcomes and the liklihoods of outcomes occurring. A formal (usually mathematical) model of the decision problem is constructed next. These judgements and opinions are synthesized along with other relevant information to arrive at a ranking of the alternatives. This ranking is in accordance with the criteria specified by the decision maker as the benchmarks for "good" decision. This synthesis is accomplished using a method consistent with the underlying axioms and theory of the particular decision analysis methodology being employed. The decision maker, having already made the judgement that these axioms and theory are reasonable descriptions of how people *do* behave and/or *should* behave, thus is both rational and consistent within the boundaries dictated by that particular decision analysis methodology.

Decision analysis can be summarized to follow four basic steps:

1. Model formulation.
2. Model evaluation.
3. Model refinement
4. Action.

This is an iterative and interactive process. Each of these steps requires the decision maker's "blessing" before the DA proceeds to the next step. Interaction between the decision analyst and the decision maker is a crucial aspect of decision analysis.

The following quote from Howard (1980) summarizes the essence of decision analysis:

> *Decision analysis serves as a vehicle for focusing all the information of experts that the decision maker may wish to bring to bear on the problem while leaving the decision maker free to accept, reject, or modify any of this information and to establish preference. (p. 7)*

The next sections provide cursory descriptions of two of the most prevalent decision analysis methodologies in use today: Muti-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process (AHP).

3. MULTI-ATTRIBUTE UTILITY THEORY

Important and complex decisions involve uncertainty, risks, and conflicting objectives. MAUT allows for the modeling of such decisions in a logical, consistent, and rational manner. The seminal work of von Neuman and Morgenstern (1947) has provided the foundation for not only modern decision analysis (in particular for MAUT), but also for much of economic theory and many behavioral theories of choice. It incorporates the decision maker's preferences, assessments of uncertainty and attitude toward risk.

The axiomatic foundation underlying MAUT is both intuitively appealing and reasonably descriptive of actual decision making behavior. These axioms provide an implicit definition of *rationality* for decision making behavior. The axioms of MAUT, simply stated, are:

> *Axiom 1: All outcomes can be ordered by the decision maker according to his/her intrinsic preference for each.*

> *Axiom 2: Given the choice between an uncertain gamble with the possibility of the worst or best outcome of the problem at hand, and a certain event with a value between the best and worst outcomes, the decision maker can adjust the likelihoods in the gamble until he/she is indifferent between the gamble and the certain event.*

> *Axiom 3: The decision maker can substitute the gamble for the certain event without changing his preferences.*

> *Axiom 4: Given two alternatives, the decision maker would select the alternative which yields the highest chance of receiving the best outcome.*

> *Axiom 5: Uncertainties are addressed through the use of probability theory.*

The decision maker systematically states his preferences for outcomes with respect to the stated criteria by which the quality of the decision will be judged. The decision maker must explicitly express tradeoffs between different levels of attainment of conflicting criteria. These assessments provide an estimate of the decision maker's intrinsic "utility function." At the risk of oversimplification, the utility function reflects the "value" of the outcomes as perceived by the decision maker. The estimated utility function also provides insight into the decision maker's attitude toward risk as embodied in the current problem.

The decision maker just as systematically and carefully assesses the level of uncertainty associated with the outcomes. This is done using established probability estimation techniques.

MAUT ranks alternatives according to "expected utility." "Expected utility" synthesizes the decision maker's preferences and values, assessments of uncertainty and attitude toward risk. The alternative with the highest "expected utility" is preferred.

Finally, MAUT allows for sensitivity analysis, which is simply the systematic variation of important model parameters to assess their impact on the ultimate decision.

Keeney (1977) provides a very readable account of how one puts multiattribute utility theory into practice. The interested reader is also referred to Howard (1980, 1988a) and Keeney (1982) for more extensive overviews of MAUT. Also, Corner and Kirkwood (1988) provide a bibliography of MAUT applications.

4. ANALYTIC HIERARCHY PROCESS

The AHP is a relatively new method developed by Professor Thomas L. Saaty of the University of Pittsburgh. He began development of AHP in the early 1970's and the process continues to be refined and improved today. While the AHP is not without adamant opponents (c.f Dyer 1990a, 1990b) there have been many applications to aid the analysis of complex decision problems with new applications appearing in the literature nearly every day. Golden, et al (1989), Saaty (1988) and Zahedi (1986) give an extensive list of applications in such diverse areas as conflict resolution, portfolio selection, budget allocation, accounting and auditing. There have been several conferences and special journal issues devoted exclusively to the AHP.

The AHP proceeds basically as follows:

1. Identify and define the components of the decision problem. These are the goal of the decision problem, the main criteria against which each alternative will be judged, the sub-criteria comprising the main criteria (also sub-sub-criteria, etc., if appropriate), the alternatives or choices available to the decision maker, and finally, the attributes possessed by each decision alternative.

2. Specify how the components are related. Delineation of the components and relationships among them results in a hierarchical model of the decision problem.

3. For related criteria, sub-criteria, and attributes at the same level of the hierarchy, determine their relative importance, priority or weighting. This is accomplished by the decision maker judging, usually in a pairwise fashion, which criterion is more "important" than the other and specifying how much more important on a nine point scale. This step results in prioritization of criteria, sub-criteria and attributes with each receiving a numerical weight. A "consistency ratio" is calculated to assess how consistent the decision maker was in his assessments of importance (priorities, or weightings).

4. Alternatives are compared, usually in a pairwise fashion, with respect to each criteria (sub-criteria or attribute) at the level of the hierarchy just above the alternatives. He or she judges which of the two alternatives measures

higher on the associated criteria (sub-criteria or attribute) and specifies, again on a nine point scale, by how much higher. These assessments are conducted either verbally, graphically, or numerically. This step results in a relative score for each alternative with respect to each criteria (sub-criteria, or attribute). A measure of consistency is again calculated for these comparisons.

5. Judgements are synthesized to determine an overall "composite priority" for each alternative. The alternative with the highest "composite priority" is the preferred alternative.

The axioms of AHP, as stated by Harker (1989, are:

> *Axiom 1: Given any two alternatives (or criteria), the decision maker is able to provide a pairwise comparison of these alternatives with respect to any criterion on a nine point scale.*
>
> *Axiom 2: When comparing any two alternatives, the decison maker never judges one to be infinitely better than the other under any criterion.*
>
> *Axiom 3: One can formulate the decision problem as a hierarchy.*
>
> *Axiom 4: All criteria and alternatives which impact the given decision problem are represented in the hierarchy.*

While these axioms might appear similar to those for MAUT, there are important differences which are manifest in the mathematical models and methods used in each technique. Fundamentally, the AHP does not explicitly estimate the decision maker's "utility function" as does MAUT. It is presumed instead, that preferences and values are captured in the "pairwise comparisons" of criteria, attributes and alternatives. Probabilities, i.e. the decision maker's assessments of uncertainty, are also incorporated differently. The AHP does not calculate "expected utility" as the basis for decision, but instead calculates a "composite priority" for each alternative.

The interested reader is referred to Saaty (1986, 1988a, 1988b, 1990), Golden (1989) and Zahedi (1986) for further detail on the AHP.

5. DECISION ANALYSIS IN SOURCE SELECTION

The need for a thorough, consistent and objective analysis is clearly recognized in the directives and regulations which guide the source selection process. As stated in Air Force Regulation 70-15/AFFARS Appendix AA:

> *The principal objective of the major source selection process is to select the source whose proposal has the highest degree of credibility and whose performance can be expected to best meet the government's requirments at an affordable cost. The process must provide impartial, equitable, and comprehensive evaluation of the competitors' proposals and related capabilities. The process should be accomplished with minimum complexity and maximum efficiency and effectiveness. It should be structured to properly balance technical, financial, and economic or*

business considerations consistent with the phase of the acquisition, program requirements, and business and legal constraints. It must be sufficiently flexible to accomodate the objectives of the acquisition and a decision must be compatible with program requirements, risks, and conditions. (p. 3)

The Federal Acquisition Regulation regarding source selection (FAR SUBPART 15.6) specifies similar objectives:

Source selection procedures are designed to:
(a) Maximize competition;
(b) Minimize the complexity of the solicitation, evaluation, and the selection decision;
(c) Ensure impartial and comprehensive evaluation of contractors' proposals; and
(d) Ensure selection of the source whose proposal has the highest degree of realism and whose performance is expected to best meet stated Government requirements. (pp. 1-2)

It seems to us, especially when one considers the complexity of source selection decisions and the research which shows the inadequacy of basing such decisions on intuition alone, that decision analysis has much to offer for this important class decision problems. We also note that source selection decisions possess all of the characteristics previously listed by Baird which make them particularly amenable to decision analysis.

Surely source selection decisions are not made on the basis of intuition alone. The central question is: *How close do current source selection practices come to bona fide decision analysis?* There are several aspects of the formal source selection process which are congruent with the established decision analysis methodologies, but there also some major differences.

The current source selection process requires that:

1. the criteria for the source selection decision be clearly specified;

2. the relative priority of the criteria be established;

3. the "risk" associated with the contractors meeting specific requirements be estimated;

4. the proposals be evaluated on the basis of these criteria, outcomes, and risks;

5. the "best" proposal be selected based upon the analysis conducted in steps 1 through 4, above.

Steps 1 and 2 are accomplished by the Source Selection Authority with the assistance and advice of the Source Selection Advisory Council. Moreover, the criteria, and relative priorities of these criteria, are explicitly provided in the Source Selection Plan. *But, however, the incorporation of risk, the evaluation of alternatives, and synthesis of judgements into the final ranking of alternatives differs significantly from how this is accomplished in decision analysis.*

"Risk" is assessed as either "high," "medium" or "low." Decision analysts would argue that these three categories of "risk" are insufficient to capture the assessment of uncertainty. "Risk," as used in source selection parlance, means something fundamentally different to the decision analyst. The decision analyst would use the term "probability" instead of "risk" to mean level of uncertainty. Moreover, there is no explicit use of probabilty theory in the current source selection process to assess levels of uncertainty. Most important, the decision maker is provided no framework for incorporating risk assessments into his final decision. He/she is left to rely on intuition alone at this crucial stage of the analysis. Decision analysis methods, on the other hand, provide theoretically sound approaches for combining probabilities with preferences and judgements to arrive at "expected utilities" (MAUT) or "composite priorities" (AHP) on which to base the ranking of alternatives.

The authors have applied both MAUT and AHP to an Air Force case study with reasonable success. Details are provided in Francis, et al (1990). The intent was to show the efficacy of applying decision analysis methods to source selection. We concluded the application of decision analysis methods to source selection results in the following advantages over the current source selection process:

1. The *axioms* of decision analysis methods are intuitively appealing and are reasonably descriptive of actual decision making behavior. Also, the axiomatic foundation for a given methodology provides an implicit defintion of "rationality," thus providing a benchmark for decision quality.

2. Methods are provided to *synthesize* preferences, judgements, uncertainties, and outcomes into ranking of alternatives as the basis for decision. The methods are logical consequences of the axioms underlying the particular decision analysis method being employed.

3. Decision analysis methods not only allow for, but in fact require, *subjective judgement.* Research (c.f. Huber et al (1969)) strongly indicates that professionals can and do develop, and reliably use, subjective evaluation models.

4. The careful and systematic analysis required to construct the decision model invariably leads to a deeper *conceptual understanding* of and further *insight* into the problem. Furthermore, communication is clarified and enhanced through the common understanding of the problem obtained from the decision analysis.

5. *Sensitivity analysis* is possible. Model parameters can be varied to assess the impact on the overall decision. Such sensitivity analysis isolates critical aspects of the problem, identifies model components requiring more precise estimation, and increases confidence in the ultimate decision.

6. There are many readily available, inexpensive, user friendly *software packages* which implement decision analysis methods. (c.f. *CRITERIUM*, 1989, *EXPERT CHOICE* 1990, McNamee, 1987)

6. PREVIOUS RESEARCH

We are not the first to investigate this issue, and it is in this section that we briefly summarize some of the recent research regarding decision analysis and source selection.

Goren (1981) identified the "major problems, deficiencies, and difficulties" with the source selection process. These deficiencies were ascertained, in large part, through an opinion survey and interviews of those working in the systems acquisition field. Goren concludes that:

> *MAUT should serve as a comprehensive, ongoing, updated, evaluation framework through the whole acquisition life cycle. (p. 133)*

Donnell and Ulvila (1980) conducted a decision analysis of the Advanced Scout Helicopter (ASH) candidates for the U.S. Army. They provided a detailed discussion of the model and its development. The AHP was used only to ascertain the relative importance of the generally agreed upon criteria. No discussion is provided about building a complete hierarchical decision model and conducting a complete AHP analysis to recommend a preferred contractor.

Cook (1986, 1987, 1989) has done considerable work in applying AHP to source selection. He (1986) used AHP to

> *...help contracting and program managers identify and evaluate the relevant criteria, subcriteria, and alternatives to be considered in formulating a comprehensive strategy, and to enable these professionals to integrate their experience, judgement, and the facts that are available into a coherent, comprehensive competition strategy. (p. 273)*

Cook (1986) applied the AHP, as implemented in the software package *EXPERT CHOICE* (1983) to select a contractor for an Air Force fighter aircraft engine. He showed the feasibility of applying this decision analysis methodology to such problems.

Cook (1989) also used the AHP to assist in a decision regarding "component breakout" to encourage competition in the procurement of major weapon systems. His paper chronicles an actual case study for the procurement of the F-15 fighter aircraft's radar system. He concludes:

> *1. The decision itself was transformed from unstructured to structured.*
>
> *2. The DSS increased group and management confidence in the decision process and in the group recommendation.*
>
> *3. The decision took less time, in the opinion of the group members, than would have been required using an alternative methodology.*
>
> *4. As a result of the imbedded documentation and audit trail, the team was able to present its findings and recommendations in a rational manner when briefing the program director, thus winning the director's approval. (pp. 11-13)*

Vickery (1989) developed a fictitious source selection case and asked a number of individuals to analyze the problem. One group was introduced to AHP and the other was not. The quality of their decision was judged according to six criteria: effectiveness, consistency, speed, difficulty, understanding, and confidence. While the AHP group reported significantly higher "speed" and "understanding," and significantly lower "difficulty," there was no significant difference in decision "effectiveness" or "consistence." Vickery offers several plausible explanations of why this could be the case, including the possibility the case was too simple. One interesting result was every person in the control group used an ad hoc method which was similar to the AHP, lending credence to the theory that the AHP "facilitates the innate decision making process" as suggested by Cook (1986).

6. CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

In this paper, we have investigated the application of two established decision analysis methods to the problem of source selection. We first described decision analysis in general and then provided very brief introductions to two of the most widely used methods: MAUT and the AHP. We then identified aspects of the current source selection process which might benefit from the application of decision analysis methodologies. Finally, we summarized some of the recent research into the application of decision analysis to source selection.

We believe both decision analysis methodologies can be effectively applied to this important class of decision problems. We are not the first to come to this conclusion. It is our opinion that the application of the decision analysis to source selection holds great promise for improving this important class of decision problems, while remaining within established regulations, policies and guidelines.

We suggest that further research might be directed at the following areas:

1. Development of a user friendly software package which implements decision analysis methods specifically for the source selection problem domain.

2. Investigation of the applicability of decision analysis to source selection in the other military services.

3. Development of a program to educate acquisition personnel about the benefits and use of decision analysis in source selection.

4. Development of a test program to further assess the efficacy of applying decision analysis to source selection.

5. An on-going survey of applications of the decision analysis to systems acquisition to more completely outline the benefits obtained and difficulties encountered.

6. Investigation into group decision making and methods of combining individual analyses into a single decision.

7. Investigation into the psychological and behavioral aspects of both individual and group decision making and the implications for employing decision analysis in source selection.

8. Investigation of the decision analysis methodology employed at Stanford University under the direction of R. A. Howard (c.f. Howard and Matheson (1984), and Tatman (1989)).

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CITIS: THE IMPLEMENTATION OF CALS PHASE 2

William L. Howard

ABSTRACT

An objective of CALS (Computer-aided Acquisition and Logistics Support) is to provide for the access to contractor generated and contractor maintained data bases of weapon system data. The service to provide this access is called CITIS. CITIS may be a requirement on all contracts for new weapon systems and may be placed on new contracts for older weapons.

Under contract to the OSD CALS Policy Office, the author has helped develop a draft Military Specification which defines what CITIS must be, what functions it must perform, and what the contractor must do to maintain the service and provide access to government users.

Introduction

It is a stated objective of CALS to provide integrated, automated support to every function (development, manufacturing, operations, and support) in the life cycle of a weapon system. There are three elements to this objective:

- Integration of functional performance,
- Automated support to functional performance, and
- The exchange of digital technical information.

For DoD to realize maximum benefit, these three elements must be implemented together as an integrated whole. That is, automation should support the integration of functional performance through the exchange of digital information. DoD can require and incentivize private sector contractors to implement these elements of CALS primarily through weapon system contracts.

CITIS

In addition to functional integration and automation, a CALS Request for Proposal (RFP) must address Government access to the digital information products that result from CALS functional integration requirements. The service to provide such access is called Contractor Integrated Technical Information Service (CITIS). CALS functional integration requirements will drive contractors to build integrated, digital data bases. However, it will take a specific contractual requirement for special services for the contractor to accomplish the extra work to make these data bases available to the Government.

The relationship of CALS and CITIS is shown in Figure 1. The CALS vision is the integration of both contractor and DoD functions. Such integration must have automated, integrated data. CITIS is the enabling service that receives, manages, and provides both the contractors and the Government with access to the data.

Thus, CITIS is a computer based service that draws upon integrated information from throughout a contractor's enterprise, contracting team and suppliers. The contractor provides services throughout the contract period to define, organize, maintain, and provide controlled access to both government furnished and contractor generated information. The service may include facilities for manipulation and analysis of the information.

Requirements for CITIS have been documented in a draft specification,

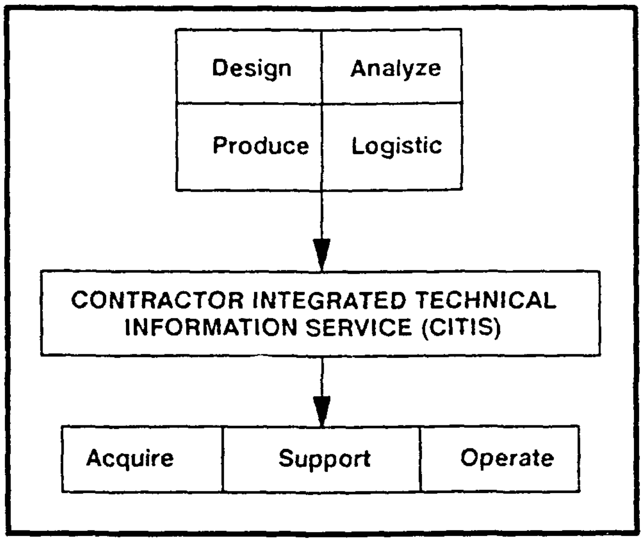


Figure 1 CALS Vision

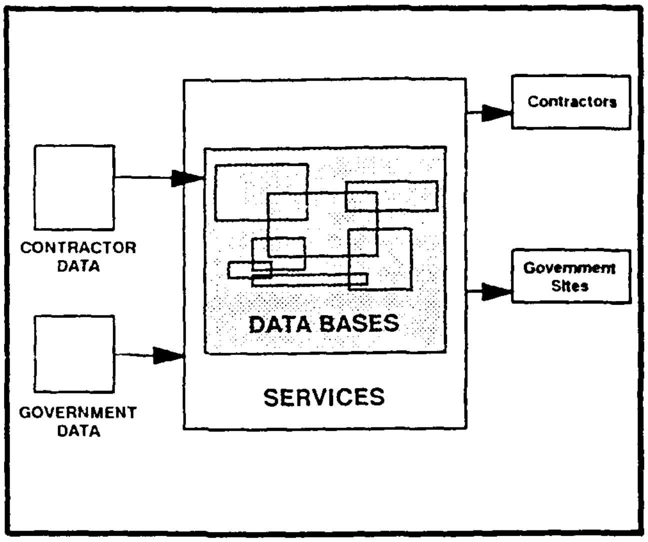


Figure 2 CITIS Services

MIL-C-CITIS which is currently in review by both the Government and industry. This specification is designed for use by DoD acquisition managers who are implementing CALS to gain access to contractor integrated information. Functional requirements are specified for a contractor service that provides all authorized government users with access to integrated information data bases. Requirements are defined for service attributes and transition, information management, access and delivery, and application services.

MIL-C-CITIS is a functional specification for services. It does not define requirements for functional integration and it does not define the contents of the data base. All requirements defined in the specification relate only to the service which provides access. Figure 2 illustrates this distinction.

Contractor personnel generate information and place it directly into the data base. Government furnished information (GFI) is received by the contractor and is also placed in the data base. All users, whether contractor or government, interface with the service to get access to the information.

Key Concepts

The assumption that the Government will furnish GFI in digital format and that it will be maintained by the contractor is one of two key concepts embodied in the specification. It is seen as presumptuous of the Government to require the contractor to deliver digital information if the Government is not prepared to furnish digital information.

The second key concept is of Levels of Service. The specification define four levels:

1. Automated selection and access,
2. Pre-defined query,
3. Ad Hoc query, and
4. Contractor applications.

These levels are generally in increasing order of sophistication and capability.

Level 1 can vary from a simple, automated accession list that only tells the user what is available and how to order it, to a sophisticated search and abstraction capability. In any case, Level 1 only functions as a card catalog in a library. It tells you what is available, but does not directly give it to you.

Level 2 provides defined responses to defined questions. This requires extensive, detailed agreement between the Government and the contractor prior to initiating the service. The agreement should be made prior to completing the data base design and start of data base build-up. For classic Contract Data Requirements List deliverables, Level 2 only eliminates the paper; it changes the mode of delivery, but not necessarily the form. Traditional reports such as a contract funds status report or a technical manual could be accessed via a computer terminal request for that specific item instead of a hardcopy print. Level 2 provides access to the data with the advantages of quicker access to the more timely and accurate information possible in a digital data base.

Level 3 removes the restrictions of predefinition of formats, combinations, and sorts. A Government user could still look at the contract funds status report, but he could specify what set of numbers he wants to see, the page layout, and combinations with other data not available in the traditional report. In its extreme, Level 3 would provide capabilities that cannot be accomplished without a fully integrated data base. For example, Level 3 could, theoretically, allow a user to combine detailed engineering drawings with the equivalent technical manual illustrations and text.

Level 4 provides access to the applications that the contractor used in generating the data. For example, a Government user could use Level 2 or Level 3 to access a contractor generated finite element model, then use a Government computer to perform an analysis of the model. Under Level 4, he would use the contractor's computer and a contractor furnished application such as NASTRAN to perform the analysis.

Acquisition Strategies

In implementing CITIS, each acquisition manager must determine which of two acquisition strategies he wishes to pursue. He can cite the specification as a source of definition, and ask bidders to propose what they will deliver. It should be anticipated that each proposal will define a baseline capability that they can provide soon after contract award and an evolutionary growth towards more sophisticated and complete services.

The second strategy is for the acquisition manager to tailor the specification and define specific services and levels for specific data items.

The first strategy might be easier for the acquisition manager. It shifts all of the analysis and planning to the bidders. However, it might not result in what is best for the Government. The second strategy might apply, in particular, to mature programs, those that are already in Full Scale Development (FSD) or Production. Even with todays technology it is probably not cost effective to try to capture into a digital data base data that was generated manually. However, many contractors have been building digital data bases for years, then documenting that data on paper and delivering only the documentation to the Government.

For programs whose contractors have an existing, digital data base, detailed specification of requirements should ensure that the Government contracts for what it can best use. The RFP should specify delivery of what the contractor has already developed. Otherwise, there is the potential that the Government will pay for digitial development of data that it has already paid to be developed manually.

It should be noted that the contractor will have to provide an implementation plan to meet either strategy. This plan, to include all CALS requirements, is called the CALS Integrated Plan (CALSIP).

Specification Requirements

The requirements section of the specification has 8 sections:

1. Information Services – This section defines the general requirements for organizing,

maintaining, and providing access to GFI and all contract specified data.

2. Implementation Planning - This section requires that the contractor plan for the implementation of CITIS. The objective is to require the contractor to build an integrated plan, the CALSIP, but a specification cannot require data, it can only require functional action. Data requirements are defined in the CDRLs.

3. Service Attributes - Attributes include configuration management, user interfaces, data formats, CALS standards, telecommunications, and hardware and software specifications.

4. Security - The contractor must follow standard Government regulations for classified data. CITIS complicates the security issue in that it puts proprietary and sensitive data at more risk of compromise than paper deliverables and it has the potential for allowing aggregations of data that are not practical with paper. Such aggregations might raise the security requirements above the requirements for individual data items.

5. Information Integration - Integration is characterized by the extent to which data is generated once and made available for use across all operations without requiring redundant data appearances and by the extent to which changes are reflected in all affected data elements within reasonable cycle times.

6. Information Management - Management services include data accessibility, file transfer, data base administration, user support and data delivery and acceptance. Delivery and acceptance includes the capability for the Government to electronically signify acceptance of data items.

7. Levels of Service - These are the levels of service described in the Key Concepts section, above.

8. Transition requirements - The Government does not want to be tied to a single, sole source for the life of the weapon system. Therefore, the contractor is required to demonstrate that the CITIS can be transferred to the Government or to a third party. There is an underlying assumption that is not made by the specification, that is that the CITIS is developed and operated by the weapon system contractor whose data forms the data base.

Conformance

Conformance can be verified and validated through tests, demonstrations, substantive audits, or procedural audits. Requirements are included for transition, performance, ease of use and data timeliness.

Tailoring

The CITIS specification has consciously been made very flexible. There are several instances where the specification requirements section lists multiple, mutually exclusive alternatives. This means that the specification must be tailored to remove those alternatives before it can be cited as a contract requirement. The NOTES section of the specification gives guidance on such tailoring. Decision parameters are discussed to help acquisition mangers determine what they want to specify.

Application Guidance

An appendix is included in the draft specification which will probably not be included in the released document. It is included because it was felt that extensive guidance is needed and is not available elsewhere.

The major part of the guidance discusses each section of an RFP and how it is affected by CITIS including a sample CLIN for services and examples of CDRLs and Data Item Descriptions (DIDs). Table 1 summarizes the action needed in each section. A CLIN is needed in Section B because the Government is buying services that are not otherwise available. Functional requirements for generating data are defined in Section C, but delivery through CITIS must be specified on the Section J CDRLs. A sample CLIN for services and examples of CDRLs and Data Item Descriptions (DIDs) are included.

Table 1 CITIS Requirements in RFPs

SECTION	TITLE	CITIS REQUIREMENTS
B	Supplies of services and Prices/ Costs	Establish CLIN for CITIS to be provided IAW SOW Service agreement for access time, connect hour, computer resource units, storage
C	Description/specification/work statement	Require CITIS by referencing the specification, require Plan, Define unique requirements Functional data and applications requirements
E	Inspection and acceptance	Specify tests, demonstrations or audits
F	Establish period of performance	Establish CITIS period of performance, development, milestones for evolutionary CITIS
H	Special contract requirements	Warranty clauses and metrics
J	Attachments	Provide tailored CDRLs and DIDs Provide DiD for ICMP
L	Instructions to Offerors	Require ICMP, IAW DID Management Section Discuss Functional and Data Integration
M	Evaluation factors	Define criteria for evaluating CITIS proposals

The most difficult part of tailoring an RFP to take advantage of CITIS is in writing Section L, Instructions to Offerors, and Section M, Evaluation Factors. The purpose of the RFP is to buy a weapon system or piece of equipment. Buying access to data is very much a secondary issue. However, integrated, digital data bases and direct access to data might bear heavily on the risk af cost overruns and slipped schedules. It is in evaluating such risk that the Government will assess contractor proposals for CITIS.

Cost Issues

There are three elements of cost that must be addressed by contractors and the Government in implementing CITIS:

1. Contractor Infrastructure - The infrastructure is the hardware and software systems the are used to generate, store, manipulate, and access the data. These costs are normally charged to capital and overhead expense across multiple contracts under the philosophy that the contractor will use the same set of systems for all Government contracts.

2. Populate the Data Base - These costs are a direct charge to the contract, but through the functional CLINs that require the data to be generated. These are not CITIS costs.

3. Provide Services for Access - These costs, including maintenance of the service, should be charged directly to the CITIS CLIN.

Schedule

The specification is under very broad review and will be changed in accordance with comments from both Government and industry. This process is expected to require several more months, but formal release of the specification is planned during calendar year 1991.

Summary

There is a specification in the review process that will affect every DoD program and every DoD contractor. Early reviews have indicated that, while innovative, the specification is relatively robust and can be expected to be released for mandatory application on many acquisitions.

Falcon PUSH - (Periodic Upgrade of Software and Hardware) - The TQM Way to Update and Field Aircraft Software

Captain Eugene J. Pickarz, Jr., Aeronautical Systems Division

ABSTRACT

The F-16 System Program Office at Aeronautical Systems Division has designed a program to reduce the fielding time for software updates on the F-16 Weapon System from approximately 36 months to 18 months (from the Systems Design Freeze (SDF) milestone). The process accelerates the contracting, development and fielding of core avionics software changes hereafter referred to as an Operational Flight Program (OFP), to the five aircraft systems processors, on USAF Block 40 F-16 aircraft. A two-phase contracting effort is utilized. First, an ongoing "sustaining engineering" effort (Time and Materials Contract) is used to evaluate change candidates up to the SDF change milestone. Second, an Engineering Change Proposal (ECP) is developed to incorporate selected candidates and field the OFP. The ECP process is greatly streamlined by utilizing a "generic" Engineering Change Description (ECD), and 14 categories of pre-negotiated Falcon PUSH unit prices. A total (Firm-Fixed Price) software update price is derived via application of the applicable unit prices to the 14 discretely bid elements for each subsequent ECP. Unit prices were negotiated for a four year period to exercise the Falcon PUSH methodology. Lessons learned from the PUSH Program's development are presented to help others implement similar streamlined procedures for other complex weapon systems/programs.

INTRODUCTION

Background. As weapon systems become increasingly complex, maintaining the internal software configurations can become a nightmare for both the contractor and the system program office which manages the system. One aspect of this is the fact that a pilot may not be able to utilize the total capability of the aircraft. This can result when hardware has capability that cannot be used because the software controlling the hardware fails to access the capability. Another facet is software deficiencies. They range from hidden "anomalies", like symbology or functional errors that surface after incorporating configuration changes, to design errors that make system operation too difficult for the pilot to perform. These problems challenge the contractor and program office to address the software change problem as expeditiously as possible. Meeting the challenge becomes the difficult part of the process.

The change process on complex acquisition programs is unwieldy and the contractual process which supports it can be even more cumbersome. This is due to a combination of factors including: system complexity, regulatory mandates, and insufficient time to get changes on contract. System complexity can drive an extensive engineering analysis spanning many months. System requirements are often delayed due to late definitization by the end-user. Acquisition regulations can mandate extensive contractual lead-times due to cost and pricing data requirements and audits. All this is compounded by the fact that a myriad of other engineering changes are constantly competing for the program office's (and contractor's) time. What results is the phenomenon of "so many changes, so little time."

This is exactly the situation that existed in the F-16 System Program Office (SPO). While managing probably the most complex weapon system acquisition program in the Department of Defense, the F-16 SPO set its goal to challenge the "that's the way we've always done it" philosophy. In the spirit of Total Quality Management (TQM) the Falcon PUSH concept was spawned. This paper will present the Falcon PUSH concept. Both the "before and after" PUSH scenarios will be discussed as they relate to F-16 software changes. The first use of the PUSH concept will also be presented. Lastly, the "lessons learned " from the implementation of Falcon PUSH will be provided to facilitate other program offices in tailoring their software update methodologies.

"THE WAY IT'S ALWAYS BEEN DONE"

General. In the 1987-1988 timeframe, the Tactical Air Command (TAC) began expressing deep concern over the length of time necessary to field a software upgrade or modification. Three years was almost typical and at least one recent software update had a five year schedule. The contracting portion alone was so extensive as to be an "entity of its own." Time spans of 240-365 days were normal from issuance of change request to the contractor until receipt of a formal Engineering Change Proposal (ECP) or Contract Change Proposal (CCP). An additional 45-60 days followed for internal SPO review and approval. After proposal factfinding sessions, another 180 days passed before the contract was negotiated and definitized.[1] Engineering development and logistics documentation followed similar tortuous trails.

The Existing Process. The software change process for each block of production aircraft was "sequential" in nature. As shown in Figure 1 on the following page, the old process consisted of three acquisition phases: contracting, engineering, and logistics. It is by increased engineering discipline and streamlining that the sequential nature of the existing process is overcome.

The Contracting Phase. Figure 2 on the following page depicts the contracting subprocess consisting of developing an Advance Change Study Notice (ACSN), the building and submission of an ECP, factfinding of the ECP, negotiations, and lastly, authorization of the work to begin. Generation of the ACSN marks the beginning of the process. This task is akin to releasing a Request For Proposal (RFP). It is a jointly developed document which must consider the end-user's needs (in this case TAC), technical complexity, requirements and capability, and lastly, programmatic issues. This step of the process has traditionally been fraught with difficulty in defining exact requirements. Typical questions are: Where do I cut-in this OFP upgrade into production?; Which aircraftwill require retrofit?; Which coefficients (or anomalies identified by the end-user) are applicable for correction in this update?; Which Pilot Vehicle Interface (PVI) changes must be added? Only when all grey areas surrounding the scope of the change have been answered and coordinated can the contractor be directed to begin a proposal.

Figure 1 - Sequential Change Process

CONTRACTING

- ACSN
- ENGINEERING CHANGE PROPOSAL
- FACT FINDING
- NEGOTIATION
- AUTHORIZATION

ENGINEERING

- FULL CANDIDATE EVALUATION
- DESIGN
- OFP DEVELOPMENT
- LAB TESTING
- FLIGHT TESTING
- QUALIFICATION
- ENGINEERING RELEASE

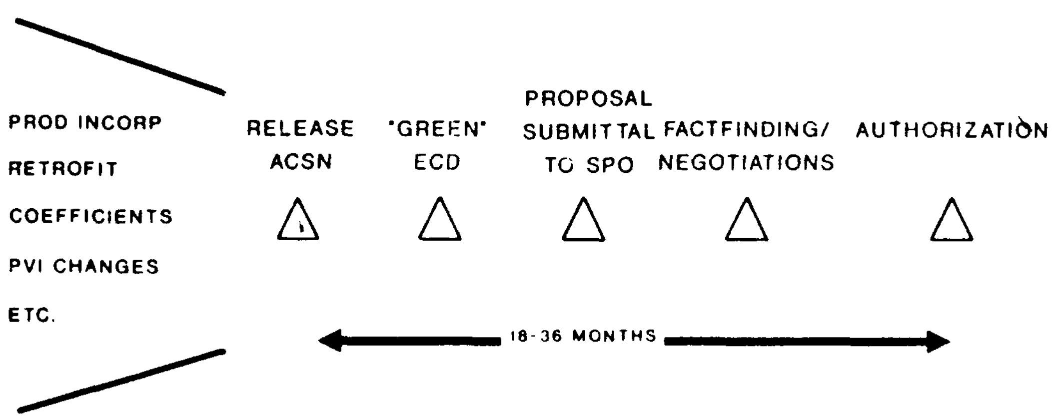
LOGISTICS

- TO REVISIONS
- TCTOs
- KIT DEVELOPMENT
- KIT PROOFING
- VALIDATION / VERIFICATION
- TO / TCTO RELEASE
- PRODUCTION INCORPORATION
- RETROFIT

[Source: GDFW Falcon PUSH Status Briefing, 29 Nov 89]

The "Green ECD" referred to in Figure 2 relates to the "first cut" on the ECD (or Statement of Work - SOW). In short, the SPO and General Dynamics Fort Worth Division (GD/FW) need to agree just what is required by the individual change. Once this is fully defined, an ECP is submitted. After submittal, any changes or areas requiring clarification must be reviewed and approved via a time-consuming Configuration Control Board process. Based on the complexity and scope of the update factfinding and negotiations can go on for many months, leading to a handshake and authorization for GD/FW to formally begin the work. When all is said and done, approximately 18 - 36 months have elapsed and the second major phase, the Engineering Phase, can begin.

FIGURE 2
PRESENT CONTRACTING CYCLE



[Source: ASD/YPDS Status Briefing, 24 Jul 89]

The Engineering Phase. The Software Engineering Phase is comprised of those tasks required to define, develop, test and document each software OFP. This process could take from 12 to 16 months or longer depending on the size of the change. It starts with candidate evaluation, which examines how software features, known as candidates, can be designed to fulfill the requirements of the ACSN. These candidates are evaluated for operational effectiveness in flight simulators and for engineering compatibility in software laboratory simulations. Once the candidate incorporation methodology is tied down, the size of the software change for the candidate is determined as a quantity of Delivered Source Instructions (DSIs). Design is then completed for the software candidate and the software "code" is written. The total OFP is developed, comprised of all previously identified candidates. Once developed, the various final laboratory simulation tests and flight testing are accomplished. The object of the testing is to determine if the software does what it is supposed to and that new candidates do not interfere with the operation of features that exist in the presently fielded OFP. Upon successful completion of testing where various "anomalies" are shaken out of the tape, the qualification process is complete. Here the traditional program management functions of Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) are accomplished. After the FCA and PCA a final review is done and Logistics (GD/FW, SPO, & TAC) can begin the Technical Order (TO) Validation and Verification (Val/Ver) process, maintenance procedures, and the subsequent final documenting of the software changes.

The Logistics Phase. The logistics functions entail documenting the software update in technical manuals, developing retrofit kits, cutting the new OFP into production and distributing updated tape cartridges for upload on operational aircraft and support equipment. While there is a minimal amount of actual "hardware" which will be retrofit on aircraft, Logistics' taskings are not simple by any means. These functions take a great deal of time due to the multiple interactions between the Air Force and the Contractor. Timely and accurate Technical Orders (TOs) are crucial for a fully supportable weapons system. The TO development process is traditionally lengthy due to both numerous changes made after final engineering release to Logistics and due to hardware reactions to the OFP (such as a display showing something that must be reflected in an illustration, which engineering didn't document). In addition, all related support equipment, test equipment and test procedures must be evaluated and updated so field personnel can maintain and trouble-shoot aircraft malfunctions. Many times, an OFP change requires extensive TO rewrites. Validation of the OFP and its related TOs is done at the contractor's plant and Verification is accomplished by the Air Force at the factory or a field location. Normally with software changes, every attempt is made to do back-to-back Val/Ver at the factory, but this is sometimes not possible. If accomplished at a field location, the Verification process can be lengthy, not because of a complex software retrofit task, but due to the extensive coordinations required to acquire and perform the verification process on fielded aircraft at an operational location. After the Val/Ver process is complete, the manuscript TOs can be released for production of formal TOs.

Production incorporation has been a continual logistics problem. This problem stems from the end-user wanting an upgrade fielded as quickly as possible. Following engineering release, the OFP is technically ready for installation in the aircraft, but must wait for development and production of the associated TOs. That effort, on average, requires 12 months to complete. Despite the goal of logistics to field a fully supportable update with full, formal TOs for both aircraft and support equipment, a decision is often made to field the upgrade prior to finishing the formal TO tasks. This drives use of manuscript TOs and large numbers of Interim Operational Supplements.

The Challenges. The SPO first initiated Falcon PUSH discussions in April of 1989 in a software working group meeting at GD/FW. After a trip to GD/FW by the then Commander of Air Force Systems Command, General Bernard R. Randolph, further interest was sparked in the software dilemma. When the reasons for the long leadtimes were presented, namely, the volume of changes, change complexity, sequential development and fluid baseline, General Randolph's response was simply "That's not a reason! How can we fix this?"[2] The response was Falcon PUSH.

The SPO recognized early on that challenging the status quo would not be easy. The existing process took anywhere from 36 months (3 years) to 64 months (over 5 years) to yield a fielded software update, depending on its complexity[3].

THE FALCON PUSH WAY

General. It was agreed to from the inception of the PUSH concept that many groundrules would need to be established for the accelerated updates. A commitment to configuration discipline by both GD/FW and the SPO was also made. At first, all F-16 C/D aircraft were targeted for application of the PUSH concept. It was subsequently determined however that the estimating effort and contractual risk from an "across-the-board" application to cover any potential aircraft effectivity was too much to attempt and still get Falcon PUSH on contract in time for Block 40 Production Tape 3 (40P3), the first formal test case.

Based on the SPO software planning horizon and the PUSH Program period of performance, the projected updates were primarily for Block 40 aircraft. So it was determined that the first major constraint would be applicability to Block 40 (USAF - ... Foreign Military Sales) aircraft. The other key goals were to limit the size of the core avionics software changes, plan well ahead and coordinate the requirements for software, software equipment and test assets, maintain baselines, avoid concurrent hardware changes, and keep the span time from Capability Feeeze (i.e. just what software change candidates would be incorporated) to supported fielding as short as possible, with a goal of 18 months. Figure 3 provides a summary of the new configuration discipline required for the first PUSH concept.[4]

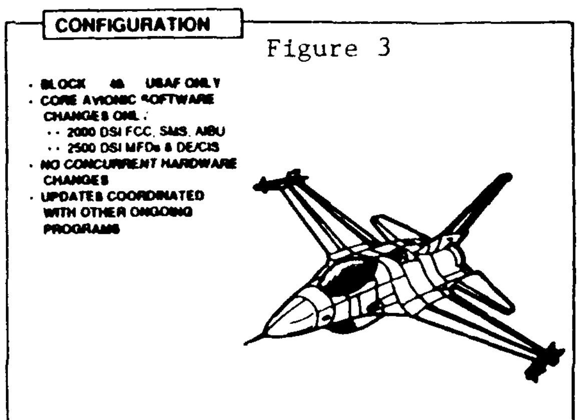


Figure 3

[Source: GDFW Status Briefing 2/6/90

What PUSH Includes and What It Doesn't. It 'is important to understand just what Falcon PUSH does. It is primarily intended to produce updates for existing systems and OFPs. It is not geared to introduce new hardware, since hardware changes are normally done through their own ECPs. PUSH addresses the numerous needed software changes that previously had to wait for the "next major Block update. These "relatively simple" change candidates can correct significant deficiencies that inhibit the pilot/aircraft interface during the protracted incorporation period of a major tape update. Thus Falcon PUSH will enable the SPO to meet many more needs of TAC faster than could have been previously possible.

Besides being initially limited to Block 40 USAF aircraft, PUSH also is limited in scope in several other areas. PUSH excludes certain software programs. One example is the Digital Flight Controls System (DFLCS). Further exclusions are Vendor Software such as those OFPs which run the Heads-Up Display (HUD) or the Crash Survivable Flight Data Recorder (CSFDR). Lastly, Government Furnished Equipment (GFE) software, such as the OFP which governs the radar systems, is excluded.

The core avionic subsystems of the F-16 system are covered by Falcon PUSH. These avionics subsystems are comprised of the Fire Control Computer (FCC), Stores Management System (SMS), Multi-Function Display Set (MFDS), Data Entry/Cockpit Interface System (DE/CIS), and Advanced Interference Blanker Unit (AIBU).

Program Discipline. Four additional key groundrules of the PUSH concept require strict discipline with respect to management of the software updates. First, a "generic" ECD (or SOW) was developed. This was pre-negotiated to preclude extended SPO review, and to streamline the contractor's internal development and review cycle time. *In short, you get a "model" SOW from* which you tailor those sections which don't apply to a particular update.

Second, an on-going Sustaining Engineering Support effort is authorized via a Time and Materials (T&M) type contractual effort. This contractual vehicle allows the SPO and GD/FW to perform in-depth analysis of software candidates on an on-going basis to define engineering estimates needed for an individual update. With the T&M effort in place, much of the engineering evaluation and analysis normally done after the software update ECP is turned on (via the sequential process) is now done before the update is actually placed on contract. Some may say this is "streamlining with mirrors" but it is not. It furnishes a steady "pool" of candidates ready for inclusion in a software upgrade, and does not pay the penalty of contracting actions for individual groups of change candidates.

The third major groundrule is that disciplined freeze dates must be adhered to. This basically means once the "line in the sand" is drawn identifying just which candidates will be incorporated into the update, that's it. You can't come in, once the process starts, and ask for "just one more change candidate." The parties involved have to make a strong commitment to keep the update baseline firm throughout the process.

The fourth and final key groundrule is that there is a limit to just how many DSI (or lines of code) a Falcon PUSH upda can utilize. The nominal DSI per subsystem are as set forth in Table 1 on the following page. It should be noted that Falcon PUSH is not a "Level of Effort." In other words, you do not buy lines of code. The DSI estimates are for pricing purposes only and are based on extensive engineering evaluation. What you actually buy is a complete software update from start to finish. The DSI limits are established based on available manpower and time required for code development. Both factors must accommodate the

Table 1 - Delivered Source Instruction Limitations for An 18 Month Development

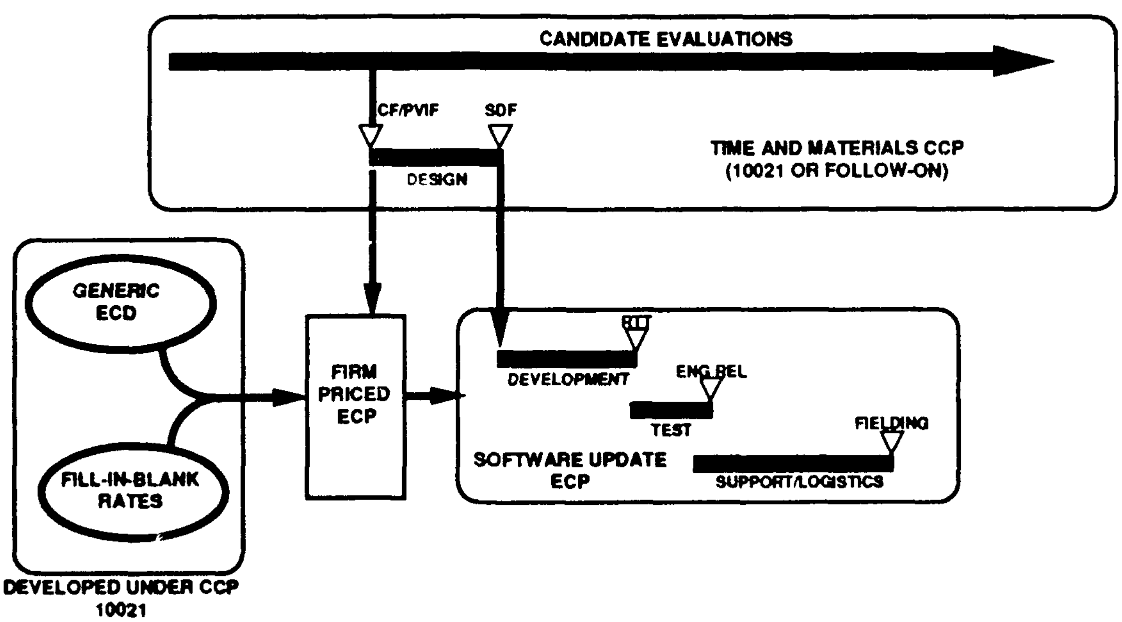
Subsystem	DSI Count
FCC	2,000
SMS	2,000
AIBU	2,000
MFDS	2,500
DE/CIS	2,500

18 month schedule goal as best possible. If a portion of the update gets too large, the manpower-time equation exceeds the PUSH goal.

The Resulting Process. The end result of many months of planning resulted in a three phase approach to make Falcon PUSH a reality. Figure 4 below shows the three phases comprised as follows. Phase One consisted of the negotiation of unit prices for fourteen different software related development tasks (for four separate years of performance), and developing a generic spend profile for each major software-related development task (to facilitate the pricing of subsequent ECPs for any period of performance needed). Phase Two was established to study the needed software update requirements and prioritize the software candidates for consideration and subsequent approval. This effort was accomplished via CCP 10021C1 (T&M). Once Phase 2 is complete, the formal ECP is developed in Phase 3 and definitized.

Pricing Rationale. The theory behind the development of the Falcon PUSH unit prices involves three major premises. First, the costs must be separated by category (See Table 2 on the following page). The unit prices must be flexible enough to reflect

FIGURE 4 - PERIODIC SOFTWARE UPDATES ACTIVITY FLOW



[Source: GDFW Falcon PUSH Status Briefing, 29 Nov 89]

Table 2 - Falcon PUSH Software Development Task Elements

Baseline Costs[5]
4 LRU Baseline Cost - All fixed costs for a 4 LRU Systems Software Update
5 LRU Baseline Cost - all fixed costs for a 5 LRU System Software Update

Flight Test - All costs to conduct a flight test

Delivered Source Instruction (DSI):
AIBU DSI - All costs to generate the required DSI for the AIBU subsystem.

DE-CIS DES - All costs to generate the required DSI for the DE/CIS subsystem.

GAC DSI - All costs to generate the required DSI for the GAC subsystem.

MFDS DSI - All costs to generate the required DSI for the MFDS subsystem.

SMS DSI - All costs to generate the required SMS for the GAC subsystem.

Drawings/Technical Orders:
CFAE - Contractor Furnished Aeronautical Equipment Drawing - All costs to generate a CFAE Drawing.
CFE - Contractor Furnished Equipment Drawing - All costs required for a CFE drawing.

Drawing - All costs required for a Drawing.
Full/Pocket Tos - All costs required for a Full/Pocket Tech Order
SD/WD - All costs required for a Schematic Diagram/Wiring Diagram
TCTO - All costs required for a Time Compliance Technical Order.

[Source: Price Negotiation Memorandum-Contract F33657-84-C-0247 - P00821]

any scenario that might occur in any particular future ECP. For example, one ECP might require 60 flight tests while another ECP may only need 45 flight tests. Thus, total flight test cost is directly influenced by the number of flights and must be separately developed to derive the correct total flight test price. This flexibility was the rationale for the agreement on the 14 task elements across the four year period of effectivity (making a total of 56 individually developed and negotiated unit prices.)

The second premise assumes that applying a single unit price for any of the 14 separate cost categories still would not give the correct price since the period of performance for any particular Falcon PUSH ECP can occur at any time within the calendar years (CY) 90 through CY93. An average unit price for this time period would therefore over-state the true price in the early years and understate the real price in the later years. Thus, four independent unit prices (one for each CY) were negotiated.

However, annual prices still did not resolve the total problem. This is because an ECP could start at any time during a given year and the fact that the generic schedule is for an 18 month period vs a 12 month period. To solve this problem, a separate spend profile matrix was developed and negotiated for each major cost category. As a result, composite unit prices can be quickly calculated by multiplying each year's negotiated unit prices by each year's negotiated spend profile percentage. The composite unit price is then multiplied by the required quantities determined in Phase Two to determine a future ECP price.

The third premise is based upon utilizing several pricing baseline parameters for each year as a pricing basis in the generic Falcon PUSH proposal and negotiated prices. These quantities in Table 3 represent the most likely quantities that will be used in future Falcon PUSH ECPs.

Table 3 - Pricing Baseline Parameters[6]

Parameters	Quan
Baseline Effort (Fixed Cost)	1
Flight Test (Variable Cost (VC))	45
Drawings/TOs (VC)	100
DSI (AIBU/GAC/SMS (VC))	2000
DSI (DECIS/MFDS (VC))	2500

Technical Discipline. As discussed earlier, once the "line in the sand" is drawn at Candidate Freeze (CF) and Pilot Vehicle Interface (PVI) Freeze (PVIF), no new candidates may be introduced for incorporation. Figure 4 (presented earlier) shows that this "baseline" is essential to generate a firm priced ECP to definitize utilizing the Falcon PUSH process. Further baseline discipline must be maintained throughout the engineering process at System Design Freeze (SDF), Release To Test (RTT), and Engineering Release (Eng Rel), to provide a stable tape configuration to perform testing and complete timely logistics support activities.

The generic schedule in Figure 5 on the next page provides further insight into the engineering discipline just discussed. Several functions must be performed in order to get the 18 month fielded update. Among these are testing in the System Integration Laboratory (SIL), flight testing, support equipment software checkout, and perhaps the most challenging, logistics.

To shorten the fielding time, several "departures from the norm" are used. First, there is only one OFP tape developed, rather than several. This has the potential threat of being unable to correct all anomalies prior to fielding the OFP. "Show-stopper" problems will always be corrected prior to fielding, but minor errors will be accepted in return for the shortened development time.[7] Also, preliminary engineering data is released for use by the Tech Order writers. These advanced Aeronautical Equipment Instructions (AEIs) allow the technical writers to get a head start on the TO development process. The Production Incorporation Review is done earlier than normal, in order to identify and correct as many anomalies as possible. Finally, the Functional and Physical Configuration Audits (FCA/PCA) are "delta" audits. These reviews look only at the differences between existing baseline OFP and the new OFP, rather than covering the entire tape.

The logistics streamlining requires a schedule to concurrently support production and retrofit. Accomplishing this arduous task calls for completed formal technical manuals six months after engineering release. This is only possible by providing the AEIs to the Logistics department much

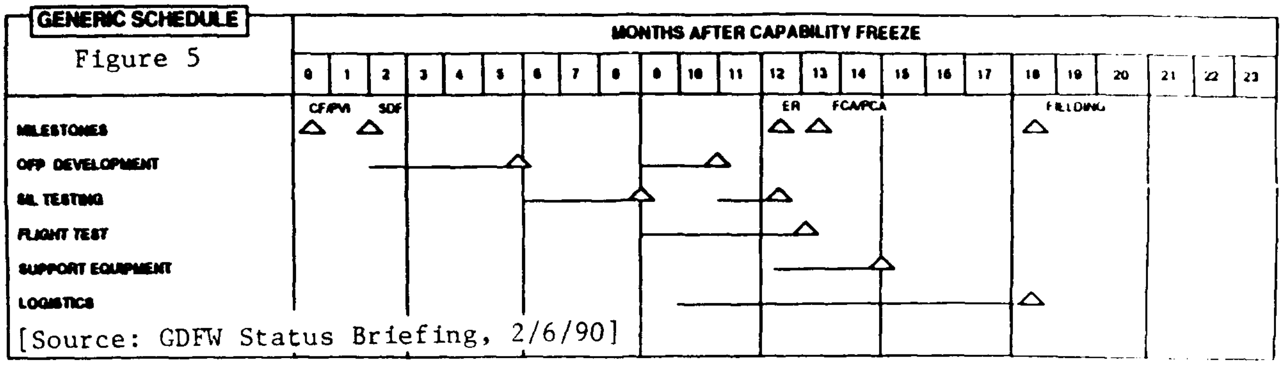


Figure 5

[Source: GDFW Status Briefing, 2/6/90]

earlier. In addition, PUSH engineering discipline requires that no changes to the technical baseline are permitted once the release is made to Logistics. A much closer working relationship and coordination process must be maintained between Engineering and Logistics than ever before.

Back-to-back Val/Ver must be accomplished not only for the aircraft effected but for the support equipment also. This is done via increased involvement by the TAC liaison office (the end-user representative) co-located at GD/FW. By performing Val/-Ver at the factory, on a product support aircraft, the time consuming field verification process is avoided. Val/Ver will substitute for kit-proofing (waived under the generic schedule). Proofing of the OFP both on the aircraft and the support equipment must be done during the Val/Ver process. These streamlined events require strict discipline by all the technical players to make the new process work. There simply isn't any slack in the 18 month schedule.

EXERCISING THE PUSH PROCESS

The First Update. As mentioned earlier in this paper, the first formal test case was Tape 3 (40P3). The development of the first Falcon PUSH ECP was done midway during the negotiations of the Falcon PUSH Phase One. Fine tuning of the methodology was thus possible and the end result was a much better contractual product and on-time definitization for the 40P3 ECP. But with every new process comes some pitfalls and Falcon PUSH has some hurdles it must overcome.

The Pitfalls. It should be obvious by now that the generic schedule is very dependent on other activities in the update process. Software engineering workload in general at GD/FW can clearly be a limiting factor. If critical problems arise on an ongoing major update or a new development effort requires extensive rework and analysis, the PUSH schedule may suffer. Closely related is the Software Integration Laboratory (SIL) workload which can create severe simulation and test limitations. On the government's side, an appropriately configured flight test aircraft and test range facilities must be available when needed, which may not always be possible. Finally, the GD/FW TO workload, which has exceeded production capacity, is a continuing F-16 challenge.

Flight testing is the last formal shakeout of the software. It is here where it is first decided whether or not the software really works as advertised. Consequently, with such an aggressive schedule from candidate freeze to fielding, a "show-stopper" here could destroy the schedules. As a result, in the event of a "show-stopper" anomaly, a decision will have to be made to pull out the candidate causing the problem (if it can even be done quickly), or rework the problem extensively. The feeling was mutual however that if you are careful enough earlier on in the process, you can avoid most show-stoppers.

The final pitfall lies with the Government Printing Office (GPO) print cycle. Once the TO manuals are completed, public law mandates that they must be sent to the GPO for printing, which normally takes 4-6 weeks. Yet another issue related to the GPO interface is the timely receipt of initial distribution instructions which must be provided by the Air Logistics Center responsible for the system. These two hurdles can create several weeks time lag from the time the tape is distributed and the technical data is received in the field.

CONCLUSION

The Benefits. The F-16 SPO hopes to complete at least three and possibly four Falcon PUSH software updates during its period of performance (CY 90 - CY 93). As a result of its implementation, the total time span from defining the candidates to incorporate to the delivery of a fielded update is projected to be only 18 months. It is important to note, however, that depending upon the candidates and estimated DSI, the 18 months schedule may be changed slightly. Both the SPO and GD/FW are committed to strive for the 18 month goal set forth in the generic schedule. The contracting process has now been shortened from the previous minimum time span of 18 months from the receipt of the proposal in the SPO to only eight weeks. This is made possible only by the fact that the majority of the upfront evaluation preceding negotiations is complete under the basic Falcon PUSH agreement governed by its own special provision. With Falcon PUSH in place there is now no need for extensive factfinding, technical evaluation, audits by the Defense Contract Audit Agency, field pricing support, or protracted negotiations. When a proposal is received, the discrete elements (number of DSI, Flight Tests, etc...) have already been virtually agreed to during the MSIP-Cockpit Review Team (MCRT) process between the using commands, test organizations, the SPO, and GD/FW.[8] All that remains is to simply apply the functions of the special provision, utilizing the rate application process mentioned earlier in this paper. In fact, a simple Lotus Spreadsheet was developed by the Price Analyst from the PUSH negotiation team whereby the discrete elements and time periods can be input and a final Falcon PUSH update price is calculated in seconds. This further eliminates pricing assistance for the contract negotiator on future Falcon PUSH ECPs.

Engineering development, which includes OFP development, SIL integration testing and flight testing, previously took from 12 to 16 months. It will now be done in 9-10 months from System Design Freeze. Much of the effort for the OFP development is done before that milestone via the sustaining engineering effort. Additional time is cut from the overall process through engineering agreement to relese preliminary AEIs for use by the technical writers.

Logistics/Fielding previously requiring 12 months now is scheduled for only seven months. This is perhaps the most aggressive goal of all due to the over-extended capacity problems which currently exist with the overall TO production process. The key here is closer coordination with Engineering during the OFP development than has ever been attempted, and Air Force assistance in expediting the Validation/Verification process. The goal is to attack the portions of the TO production process which you have the most control over, and free up time to overcome capacity constraints.

Lessons Learned. During its development, Falcon PUSH taught us many lessons. These can be grouped into three categories: continuous improvement, coordination among acquisition disciplines, and common sense contracting. One of the basic tenets of TQM is the concept of continuous improvement. We found that you must "throw out" the mindset that you "can't do something different", and continuously search for ways to improve the process. There were many occasions where parties from both the SPO and GD/FW said it couldn't be done. It was only by the determination of the PUSH team (the SPO and GD/FW) that Falcon PUSH ever came to be.

Coordination among various acquisition disciplines proved to be another significant hurdle. For example, during the coordination and negotiation of the "generic" ECD the logistics people at GD/FW were initially left "out of the loop" with regards to many of the "groundrules" required in all ECPs, until the 40P3 proposal was generated. This caused great confusion because negotiations were nearing completion and this problem raised new issues to deal with. Many of these issues stemmed from a "that's the way it's always done" attitude by persons who were never part of the Falcon PUSH team. In other words, they simply didn't know what we were doing. Had they been in the coordination cycle from the very beginning, significant time could have been cut from the negotiation process. In yet another situation, some logistics tasks were inadvertently "left out" of the proposal and surfaced when negotiations were virtually complete. Again, it was a case of not letting everyone know what the requirement was early on.

The final lesson learned was that you simply must use common sense contracting. This means: don't make it any more complex than you absolutely have to. At one point, GD/FW thought they must price out each and every task and department to arrive at a separate price. This could have led to a hundred or more possible prices to estimate and negotiate. Clearly this was not the goal of Falcon PUSH. Changing the existing mindset required additional education on what the Falcon PUSH concept entails. In short, several months were lost in developing the basic PUSH proposal which could have been saved had the message been received more clearly. In the end however, the SPO was able to concurrently negotiate and tailor both the basic ECD and PUSH procedures for individual PUSH ECPs which led to a better contractual product.

Only time will tell if the SPO and GD/FW - can make Falcon PUSH perform as advertised. Both parties feel that the concept can be expanded to other blocks of aircraft and other possible applications. The successor effort to the T&M sustaining engineering effort is currently in work and the 40P3 effort is currently on schedule. Falcon PUSH is not the panacea for all software updates. It does have some strict limitations, but you need to start somewhere. The goal in systems acquisition is to timely meet the user's needs with systems that work. Only by radical thinking and a commitment to challenge "the way we've always done it" can the goal be met.

BIBLIOGRAPHY/ENDNOTES

1/ HQ AFSC/PKPS Talking Paper, 30 May 89

2/ HQ AFSC/CC Memo, 15 Jun 89 (Attached to 1 above)

3/ The 36 month period referenced earlier refers to the average time period from System Design Freeze to Fielding.

4/ Future Falcon PUSH methodologies are planned to be applicable for multiple F-16 production blocks.

5/ A single update will require only a 4 LRU update or a 5 LRU update. A pre-priced unit price for each is required since the cost differs between the two.

6/ Price Negotiation Memorandum, dtd 10 Jul 90, Contract F33657-84-C-0247-P00821

7/ A show-stopper refers to a problem found in integration or flight test that is either safety-of-flight or a problem severe enough that precludes the pilot from performing the mission.

8/ MSIP - Multi-Staged Improvement Program

ADVANCED INTERDICTION WEAPON SYSTEM: "A QUALITY BASED PROGRAM"

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ABSTRACT

In June 1989, the Advanced Interdiction Weapon System (AIWS) was selected to implement the acquisition initiatives contained in the Defense Management Review (DMR) and to be managed as a Quality Based Program (QBP). In the absence of specific guidance regarding the elements of a QBP, the Program Manager was given a high degree of freedom in instituting the methods addressed in the DMR. This paper discusses the acquisition principles applied for enhanced acquisition management and assesses the achievements and problems encountered in managing a QBP.

INTRODUCTION

Concurrent with the Milestone I Defense Acquisition Board (DAB) review of the Advanced Interdiction Weapon System (AIWS), the report on the Defense Management Review (DMR) was nearing completion. During the AIWS program review conducted by the DAB on 5 June 1989, the Director (Air Warfare) of the Office of Tactical Warfare Programs proposed the selection of AIWS as the initial program for implementing the DMR acquisition methods. In his discussion, the Director used the term" a quality based program" or QBP to characterize what he envisioned the AIWS acquisition to be under DMR guidelines. Since that time, the AIWS has been commonly referred to as a QBP.

Deciding that AIWS was to managed as a QBP was a relatively simple matter. Defining the elements of such a program was more complex. In approving the initiation of the AIWS demonstration and validation (DEM/VAL) phase, the Milestone I Acquisition Decision Memorandum (ADM) also directed that a team from the Office of the Secretary of Defense (OSD) and the Navy, with participation by the AIWS DEM/VAL contractors, develop a plan for implementing the DMR acquisition initiatives.

Several questions emerged in the initial QBP planning meetings held by the OSD and Navy team. Representative of those questions were: what are the unique attributes of the AIWS acquisition which made it suitable for DMR implementation?; what makes a QBP different from other system acquisitions?; and how can we best capitalize on those differences to make AIWS a model for emulation? As we began to find answers to those questions, the characteristics of a QBP also began to take form.

AIWS: THE QBP CANDIDATE

Beyond the coincidence of near simultaneous promulgation of the DMR and its milestone event, there were several other reasons that AIWS was a logical candidate for practical application of DMR initiatives.

Perhaps most influential was the fact that the program was at the beginning of its acquisition cycle when it is most adaptable to institution of policies and practices outside the realm of "business as usual". Additionally, since the AIWS DEM/VAL involved three contractors and was planned for an eighteen month duration, there was ample opportunity to obtain a cross-section of ideas from the contractors and sufficient time to identify, evaluate and implement QBP initiatives before committing the program to Full Scale Development (FSD).

Secondly, the program scope and structure, in terms of cost and complexity, contributed to AIWS selection as a QBP. In the context of major system acquisitions, AIWS barely breaches the major system cost thresholds. However, the system acquisition involves the development and deployment of a baseline and Pre-Planned Product Improvement (P^3I) of the baseline variant with a degree of concurrence among the two. That strategy provides opportunities for the use of innovative contracting methods; depends on program stability to the maximum practical extent; produces major demands on the system acquisition staff; requires continuous and effective communications with the user; and benefits from clear command channels. All of these are elements of the DMR which we believed could be influential in the AIWS program.

Thirdly, as a standoff launched, low cost, general purpose air-to-surface weapon AIWS will meet the long standing requirement of operators for a weapon which can be procured in sufficient quantities for use in threat areas for improved aircraft and aircrew survivability. AIWS is the planned replacement for several aging and logistically burdensome weapon types in the inventory and, by replacing those weapons, will provide a major contribution to improved combat readiness. The combination of these factors has given the AIWS strong constituent support and made its acquisition is a high priority within naval aviation.

As the designated common interdiction weapon system in the OSD's Joint Standoff Weapons Master Plan provided to the Congress, AIWS and its successful acquisition is of interest both in the Navy and within OSD staff. These factors; a strong operational need for which there is no viable alternative and constituent support within the DOD, increases the probability that AIWS will remain a high interest acquisition and retain support through its full acquisition cycle.

Finally, by design, the AIWS provides inherent flexibility for integrating system improvements to counter emerging threats or capitalize on evolving technology to decrease system cost. The initial P^3I effort is but the beginning of what is planned to be continuing improvements, as they are required, to keep the weapon viable in a dynamic environment. Because of the system's planned durability and longevity, any investment in acquisition quality improvements now will provide long term benefit as the weapon continues to evolve and respond to new requirements.

In the aggregate, the factors identified above convinced us that the timing and the strategy for the AIWS acquisition made it an excellent choice for putting the DMR acquisition methods into practice. The next step was selecting those DMR elements for turning AIWS into a QBP.

DEFINING THE AIWS QBP

Under the guidance of National Security Review (NSR) 11, the principal objective of the DMR was to achieve major defense management improvements through implementation of the Packard Commission recommendations and by institutionalizing the requirements of the Goldwater-Nichols Defense Reorganization Act of 1986. To accomplish that objective, the DMR addressed a host of specific actions to be taken by the OSD staff and/or the military departments in four areas; personnel and organization, defense planning, acquisition policies and procedures, and improved accountability by both government and industry . Although all those areas included actions relevant to the AIWS as a QBP, the area most directly applicable at the program management level was that area focused on acquisition policies and procedures.

It may be recalled that the Packard Commission examined both defense and commercial programs and identified six underlying features typifying the most successful. Those characteristics; clear command channels; program stability; limited reporting requirements; small, high quality staffs; communication with users; and prototyping and testing, became the basis for defining the AIWS QBP initiative.

Although the DMR did not specifically stress Total Quality Management (TQM) in defining its acquisition improvement initiatives, the text of the report clearly indicates that many of the TQM methods advocated by Dr. W.E. Deming in his book, "Out of the Crisis", were influential in developing the changes to the acquisition process.

Since, as a matter of policy, the Naval Air Systems Command (NAVAIRSYSCOM) had previously adopted TQM and had initiated training for its implementation, we were well aware of positive benefits TQM could bring to program management. Consequently, as we considered the application of the six Packard Commission recommendations to the AIWS program, we evaluated each in the context of the TQM discipline.

Following the initial OSD/Navy team meetings in which the fundamental elements of a QBP were defined, the team went on the road to visit each of the three DEM/VAL contractors. The principal purpose of those meetings was to discuss and identify actions which could be carried out by the government and the contractors to solidify AIWS as a QBP. During those visits, contractors were invited to discuss in-house TQM programs and plans for ensuring quality from subcontractors. The agenda for those visits included discussions of issues such as how best to structure a program for quality; potential impediments to success; methods for measuring success; risk management and funding; program scheduling, event based performance assessment; cost estimating and reporting; auditing and auditing frequency requirements; contract types and incentives; and acquisition streamlining.

Meetings with the DEM/VAL contractors and internal discussions among the government team members reinforced the need for timely, effective communications, both within the various government participants and between the government and the contractor. Those meetings also highlighted the value of the contractor's internal contributions to quality through the use of concurrent engineering practices and system engineering "tools" such as DOD Directive 4245.7 "Transition from Development to Production"; the so-called "Willoughby Templates".

This planning effort led to the articulation of a cultural environment, incorporating the principles of the DMR, for AIWS program management which encouraged initiative and innovation within the NAVAIRSYSCOM headquarters, the program office, and field activities. Implicit in such an approach was the expectation that everyone involved in the program was ready to accept the new system acquisition philosophy. As we were to discover, that was not universally the case.

SCORECARD

Approximately sixteen months have elapsed since the QBP process began to evolve. During that time, we have made some significant strides, but we have also experienced the frustration of attempting to introduce acquisition management innovation in an environment still largely encumbered by a "business as usual" syndrome.

To a great extent, the obstacles we have encountered stem from the fact that the DMR acquisition reforms have yet to be transformed into definitive guidance for the military departments. Until the revised DOD Directive 5000.1 and Instruction 5000.2 are promulgated and implemented fully by the services, a QBP like AIWS will continue to be an "oddity"; not a way of life.

Relative to the system acquisition principles articulated in the DMR, the following is an assessment of our near term results from our venture into AIWS QBP management.

Clear command channels. As defined in the DMR, clear command channels implies ". . . clear alignment of responsibility and authority, preserved and promoted through short, unambiguous chains of command to the most senior decision makers". The objective is to confine management accountability within a streamlined chain of command to capture all cost, schedule and performance features of major programs.

The Program Executive Officer (PEO) structure, an integral part of the Navy's establishment of a streamlined command chain, was instituted in mid-April 1990 and the AIWS program has been functioning under that structure since that time. The Program Manager (PM) charter, which complies with the actions directed by the DMR, has been drafted and is expected to be implemented concurrent with the AIWS Milestone II event planned for November 1991.

The fact that the PM is responsible only to the

PEO with respect to AIWS program issues has proven to be effective and beneficial. In the few instances in which program matters have surfaced which were beyond the ability of the PM to resolve, elevating the issues to the PEO has produced expedited senior management attention with rapid problem resolution. A significant reduction in the number of repetitive program management reviews for AIWS has been noted with a net gain in PM and program office productivity.

Unfortunately, the concept of clear command channels extending from the PM to the NAVAIRSYSCOM headquarters functional support groups and field activities is less streamlined. The command operates under a matrix management structure in which key technical management functions such as contracting, logistics, systems engineering, and production engineering are provided to the program by technical specialists assigned to organizational entities other than the program office. The matrix organization makes sense with respect to efficient utilization of personnel and technical expertise. However, that type of organization creates a situation in which functional support specialists are answerable to both the PM and the head of the organization to which they are permanently assigned. In several instances we have found that efforts to introduce innovation in technical management areas have been only moderately successful. When problems have occurred, the principal cause can often be traced to a conflict between the direction of PM in introducing innovation and directives and procedures imposed by respective functional groups which have not yet fully embraced system acquisition reform.

Similarly, the PM is highly dependent on the AIWS lead field activity and participating field activities for execution of technical support functions. As in the case of the headquarters matrix organization, efforts to introduce innovation at the field activity level has, on occasion, been tempered by entrenched local policies and procedures not necessarily in step with the DMR.

Stability. The DMR characterizes program stability as an environment of funding and management stability, predicated on an agreed baseline of cost, schedule and performance. Elements of this initiative, as addressed in the DMR, include active participation by the Service Acquisition Executive (SAE) in programming and budgeting cycles, changes in law to revise the thresholds for more flexible multiyear contracting, and ensuring continuity in program management by retaining the successful PM through an entire Milestone phase.

From the PM perspective, the critical triad of program stability consists of a well defined requirement, reflected in a system cost and performance baseline, to which the user and senior decision makers agree; an acquisition strategy for translating the baseline into a producible, deployable system; and funding for executing the acquisition strategy.

Significant progress has been achieved in creating a stable AIWS program in the context of an agreed upon baseline with respect to system cost and performance. A major effort has been made to keep the user involved in the AIWS from the program's inception and those efforts have paid off by a consensus in system performance required in both the baseline AIWS and its P^{3}I variant.

A potential issue is the ability to resist "requirements creep" as the acquisition progresses. The baseline AIWS is expected to enter full production in fiscal year 1997 with the P^{3}I variant to follow 2 to 3 years later. Given the dynamics of technology, a concerted effort must be made to keep us focused on the system we have agreed to produce and resist the temptation to add capability except through a future P^{3}I or major block upgrade.

An acquisition strategy has been developed and approved which will enable us to satisfy the operational performance goals of the AIWS cost effectively. The "hooker" in optimum program stability is the availability of funding to execute the acquisition strategy. Funding stability is a function of both total resources allocated and the timing of the allocation. From the PM's perspective, both are equally important. So long as we must live with annual budget appropriations, often including unexplained decrements, it will be difficult to achieve true stability in major system acquisitions. Relief for this problem is not a unilateral DOD action and can probably only be achieved in the long term if DOD and the Congress can work constructively towards more productive funding stability.

Limited reporting requirements. Efforts to reduce the plethora of overly detailed, confusing, frequently contradictory laws, regulations, directives, instructions, policy and other guidance is a long term effort which has commenced, but not yet produced a significant change at the PM level. As directed by the DMR, a joint task force composed of representatives from OSD and the services, is conducting a "zero-based" review of regulatory and other guidance affecting DOD's system acquisition, procurement, logistics, and related activities. It is anticipated that the results of the joint task force effort will reduce the frequency and/or redundancy of regulatory requirements which often inhibits the exercise of individual judgment and creativity.

In the interim, the AIWS program implemented the intent of this DMR initiative by conducting an independent review of reporting requirements to be imposed on the successful bidder for the AIWS FSD contract. Through the use of a "zero-based" review of proposed contractor reporting and deliverable requirements, it was possible to achieve a 40% reduction in the number of contract data requirements list (CDRL) items for the FSD contract. This was accomplished with no loss of management effectiveness or control.

At the time we started putting the AIWS FSD request for proposals (RFP) together, it was the intent to utilize a team of government and DEM/VAL contractor personnel to draft the statement of work and performance specification. Among other things, the objective of this collaborative approach was to avoid the rigid imposition of government standards and specifications to the maximum practical extent and encourage the FSD bidders to submit innovative proposals. That approach was opposed by the program's technical supporting resource which presented a convincing argument that government personnel could produce a better product with less effort in less time. As it turned out, little time was saved through the in-house approach since the quality of the original product required extensive revision before it could be distributed.

Smaller, higher quality staffs. The DMR focused on legislative solutions and training for increasing the professionalism and efficiency of the civilian and military system acquisition workforce. At the program office level, the focus has been on a "boot-strap" approach to achieve the benefits of TQM points 6 (institute training) and 13 (encourage education and self-improvement for everyone) as articulated by Dr. Deming. The Defense Systems Management College (DSMC) is a major resource, utilized extensively, in improving the professional knowledge of both the civilian and military staff. The PM, deputy PM, and the deputy for systems and engineering are graduates of the formal DSMC program management course and several civilian staff are enrolled in DSMC correspondence courses.

As is the case in most NAVAIRSYSCOM program offices, the AIWS program office has insufficient staff to attend to the multitude of details associated with the program. To circumvent this problem, tasks have been realigned between the program office, NAVAIRSYSCOM functional groups, and field supporting activities. Along with this realignment, functional responsibilities have been delegated where it makes sense to do so.

To ensure control of task decentralization, the program participants, both government and contractors, are linked through an electronic mail network using common computer capabilities. Since the DEM/VAL contractors and government activities are dispersed geographically, video teleconferencing resources are used extensively to keep all participants aware of program issues, problems, and achievements.

Communications with users. A strong point on behalf of the AIWS program was the attention paid to the user of the weapon system from the beginning of the program. The genesis of AIWS was the Navy Strike/Anti-Surface Warfare Master Plan first promulgated in 1985. That plan, a part of the Navy's continuing mission area analysis, identified deficiencies in current weapons and defined desired remedial operational capabilities. The AIWS concept was one of the required capabilities addressed in the Master Plan.

In the 1985/86 time frame, a team of user representatives, supported by representatives from the technical community, was assembled to produce a draft Tentative Operational Requirement (TOR) for the system. The purpose of the TOR is to define required capabilities, in relatively non-specific terms, to be used as the basis for the production of a Development Options Paper (DOP). The objective of the DOP process is to identify and evaluate a range of technical alternatives which can provide the type of capability expressed in the TOR. The DOP provides information for translating a system capability concept into a set of operational parameters documented in a validated Operational Requirement (OR). As the AIWS OR was being drafted, the user, represented by members of the staffs of the Naval Strike Warfare Center and Marine Air Weapons Training Squadron One, as well as Fleet commands, was an active participant.

The AIWS OR documentation process resulted in a flexible requirement definition which stressed <u>what</u> capability was to be acquired; not <u>how</u> that capability was to be achieved. The intent was to encourage innovation on the part of contractors in developing their AIWS prototypes. The flexibility inherent in the OR has permitted DEM/VAL contractors to conduct trade studies to balance cost, risk and performance in the design of their prototype models. The validity of that non-restrictive approach is reflected in the three DEM/VAL prototypes which, while different, have the potential for meeting the Navy's need for AIWS.

The operational orientation, the "voice of the customer", initiated at the inception of the AIWS program remains a vital part of the system acquisition. An Operational Advisory Group (OAG) meets at least semi-annually to assess program progress and assist in addressing issues with user implications.

The interaction with the OAG extends beyond the program office to include the DEM/VAL contractors. Periodically, the contractors have met with the OAG to discuss various technical approaches and to obtain operational insights which may not otherwise be available. Additionally, the PM has been instrumental in ensuring that contractor personnel have had the opportunity to visit onboard an aircraft carrier to experience, first hand, the environment in which the weapon they expect to produce will be employed. The functions of the OAG in the AIWS program have become institutionalized and will extend into the FSD phase and subsequent system acquisition efforts.

Prototyping and testing. The Packard Commission found that, in the most successful programs, systems or subsystems involving unproven technology is tested under simulated operational conditions before final design approval or production.

With respect to the AIWS, the original DEM/VAL approach involved only analytical studies, supported by wind tunnel tests, as a precursor to a FSD decision. There was some risk in that approach since the AIWS is dependent on airframe kinematic efficiency for meeting its operational objectives and analytical studies may not have revealed the performance attainable in the operable system. A change in public law, which imposed prototyping requirements for major weapon systems, combined with a concern that analytical studies would not provide the level of confidence needed for a Milestone II FSD decision prompted the PM to revise the strategy to include prototyping and testing of the DEM/VAL contractor's concepts. Having made that decision, the PM used the "clear command channels" to obtain additional funding required to support the revised system acquisition.

As a result of that decision, the prototype model produced by one of the DEM/VAL contractors was successfully demonstrated in early December 1990 and those of the remaining contractors will be flown in early Spring 1991. The demonstrated performance of these prototypes will provide the DAB members with a better estimate of risk and other information needed to assess the program adequately and provide a basis for confidence in supporting the Milestone II decision.

SUMMARY

Involvement in the structuring of the AIWS as a QBP has been a challenging and enlightening experience. The absence of a "cookbook" solution in creating a QBP has permitted the task to be approached with innovation and initiative. Positive results have been achieved which, overall, have confirmed the validity of the DMR's acquisition improvement initiatives. The process has also revealed numerous issues which must be addressed if real progress in acquisition reform is to be achieved. A system acquisition program is dependent on multiple resources. Significant results from an initiative such as the QBP will be constrained unless those resources are conditioned to respond to acquisition reforms at the same pace and level as the program being supported.

The ultimate measure of effectiveness of the initial efforts in QBP will be determined at the AIWS Milestone II decision forum. In the interim, we will continue to invoke Dr. Deming's point 5, "Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs". That takes hard work and attention to detail, but we will do it!

Assessing the Costs and Benefits of CALS for On-Going Weapon System Programs

Dr. W.L. Scheller II, TASC

ABSTRACT

CALS is the DoD initiative which offers the possibility of significant savings during all periods of the acquisition life-cycle. Given that most of the systems currently in production or fielded will be in the inventory for the forseeable future, the questions of CALS benefits and implementation costs arise for those systems. This paper examines the benefits of CALS in reduced costs of design and transition to production, more efficient maintenance operations and reduced ordering and inventory costs. Costs of implementation are examined as well. These areas of benefit and cost are then applied to existing systems. As a result of these investigations, a conservative estimate of the benefit cost ratio is made. That ratio is estimated at at least four to one. Therefore, it is concluded that CALS can bring significant cost reductions even to systems already in the field.

INTRODUCTION

Computer-aided Acquisition and Logistic Support (CALS) is the Department of Defense (DoD) initiative to "... enable and accelerate, the integration of digital technical information for weapon system design, manufacture and support."[1] Figure 1 illustrates the basic concept of using common databases and a common interface to improve the efficiency of program management. CALS began five years ago with a policy memo from the Office of the Secretary of Defense (OSD) and the establishment of the OSD CALS Policy Office. Since then DoD has been working closely with industry and the National Institutes of Standards and Technology (NIST) to define and implement significant portions of the CALS concept.

CALS shares many of the attributes of Computer Integrated Manufacturing (CIM), yet is unique in many ways. CIM is a concept for integrating design and production functions. It is focused on factory integration and the use of advanced manufacturing and computing technologies. Work in CIM began in 1975. The Venn diagram in Figure 2 illustrates both the similarities and differences between CALS and CIM. CALS and CIM are mutually complemetary approaches to many of the same problems, specifically integrating data for purposes of design, production and management. CALS and CIM share many common concepts. Concurrent Engineering (CE) is the name associated with the simultaneous design of both product and manufacturing process. It also can include design of the necessary support facilities.

In order to create the design and bring it into production, both contractor and Government need to have access to the information most important to them at critical times. Aggregation of this data in a common database not only eases the contractor's job of product and process design, but eases the Government's job of review and monitoring, because all of the necessary data can be accessed through the common database. In this respect, CALS and CIM share many of the same implementation costs.

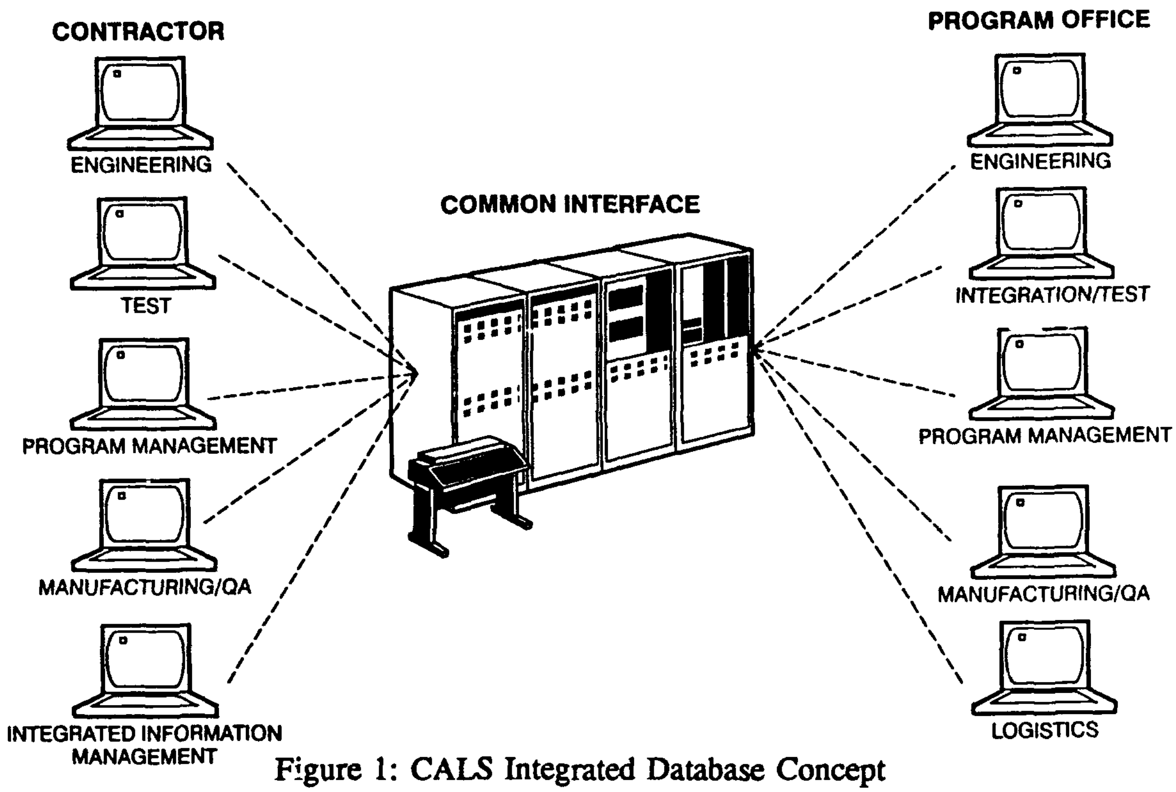

Figure 1: CALS Integrated Database Concept

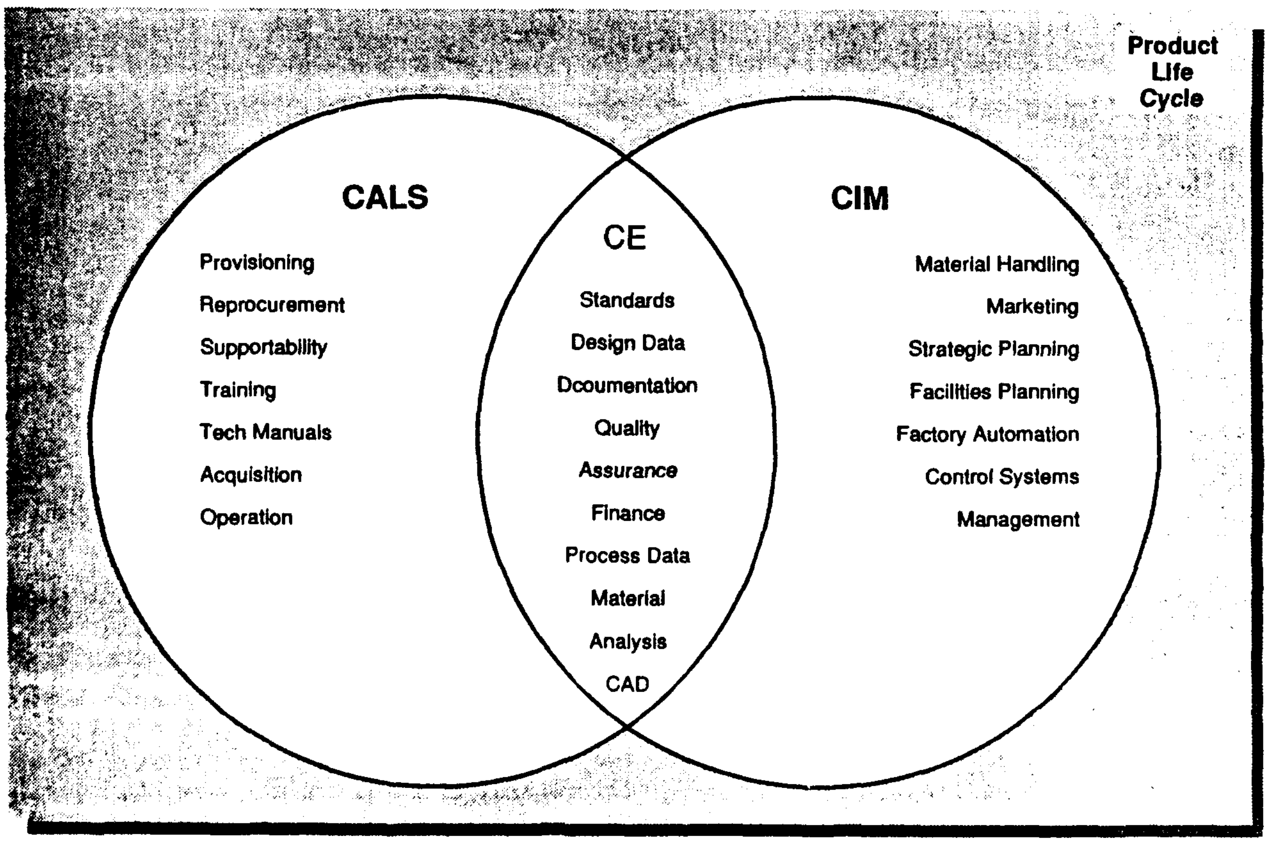

Figure 2: CALS and CIM

CALS can be applied to existing, on-going programs ("legacy systems"). Indeed, many of the deliverables for current programs are produced using automated data processing (ADP). Therefore, regardless of the final delivery form many of the deliverables already exist in digital form. The challenge is to make those deliverables available in that form. The Contractor Integrated Technical Information Service (CITIS) is designed to address many of these problems.

The CITIS functional specification (MIL-C-CITIS), prepared by TASC for the OSD CALS Policy Office, for the first time will integrate digital data in a form accessible by Government managers. As is shown in Figure 3, there are four levels to this service, each level being more detailed than the previous one. The first level of service within CITIS will be an automated accession list. Level two will allow pre-defined queries to be made. Level three will support ad-hoc queries of the database. Level four will actually allow the Government to run contractor applications directly. Legacy systems will need to focus on levels one and two. What CITIS will provide is a means of access to data, it is not however itself an integrated analysis tool.

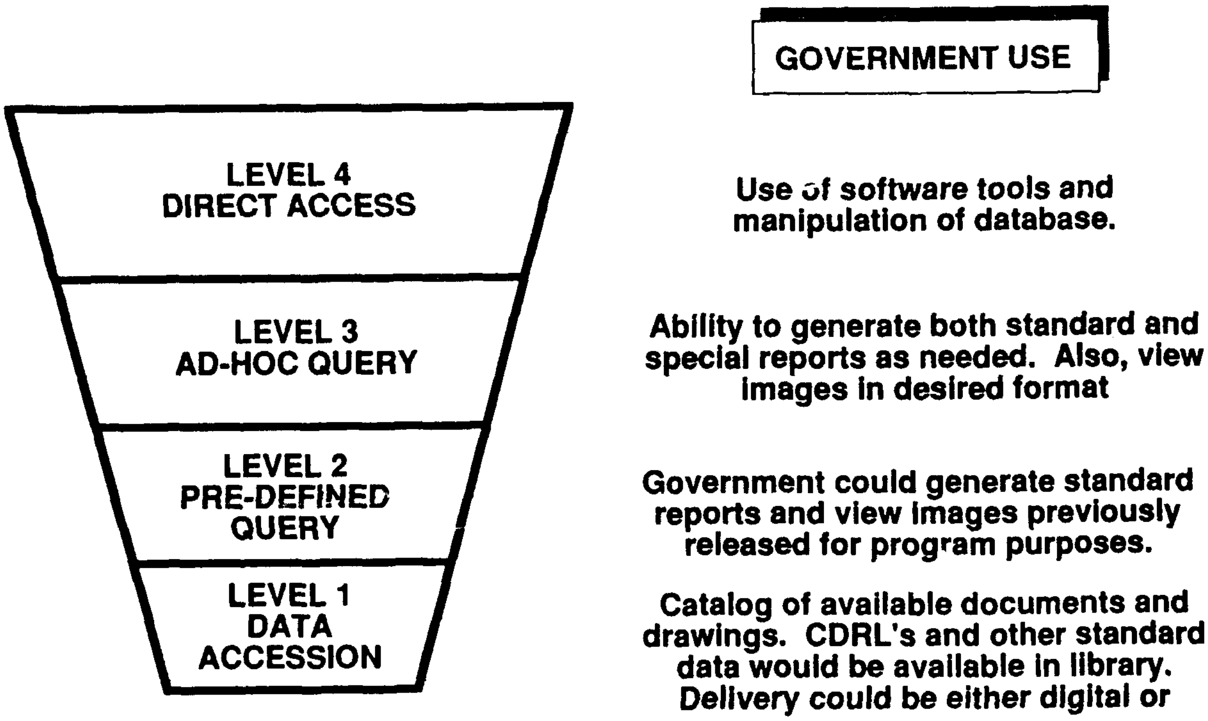

Figure 3: Levels of Service in CITIS

BENEFITS

The benefits to be attained from CALS implementation on a legacy system are many for both the Government and contractors. It should certainly be worth the pain of transition. Some of these benefits will incude:

- Reduced design and transition to production costs
- Reduced costs of maintenance operations
- Reduced ordering and stocking costs.

Each of these areas will benefit the Government, contractors or both organizations. Each of these areas will impact cost. Again, CALS and CIM share many of the same attributes and benefits may be expected to follow the established patterns for CIM shown in Table 1. Specifically, the areas of:

- Computer-Aided Engineering (CAE)
- Computer-Aided Manufacturing (CAM)
- Computer-Aided Quality Control (CAQC)
- Computer-Aided Process Control (CAPC)

will have significant impacts on total system cost.

The CE portion of CALS and CIM promises to reduce design and transition to production costs. This will result from shorter times for the concept to production on new products cycle, thus creating multiple savings opportunities. Table 2 presents savings achieved through the use of CE. Reductions include base labor rates, improved productivity, quality and reduced scrap. One system, AN/TSQ 73 had savings specific to logistics.

In legacy programs, CE will be most beneficial in the design, development and production/implementation of modifications. CE will make a stable design database available to engineers through CITIS. Savings from CE can be expected to be 20% of design costs. The savings from CE will be tied to the level of CITIS implementation, since this level determines the availability of current design information to engineers. The higher the level of CITIS implementation, the more benefit that will be derived from its use, since greater access will be provided to design data and the tools which generated it.

Data availability in the field is an area of extreme importance. Improved systems for delivering maintenance data to technicians will reduce overall maintenance costs, by making the process more efficient. Spoilage and loss of paper manuals is a problem, as is the maintenance of systems with changing configurations. Indeed, a system which is produced in large volume (e.g. F-16) not only will have standard variants, but individual units may have unique configurations. Availability of drawings and other documentation relating to individual units could be made available through CITIS to support field activities. This will reduce the overall cost of maintaining systems.

Just as data availability will assist in field maintenance, it will also reduce costs of ordering and stocking parts. Ordering parts will be made easier, since the necessary technical data will be readily available. This is especially important in legacy programs where the original manufacturer may no longer have the production capability or where competition for supplies is desired. The tracking of parts stocks will not be part of CITIS, however inventory systems (e.g.

Table 1: Benefits of CIM

AMOUNT OF IMPROVEMENT	FACTOR	CIM COMPONENT
15 - 30%	REDUCTION IN ENGINEERING DESIGN COST	CAE
30 - 60%	REDUCTION IN OVERALL LEAD TIME	CAE, CAM
2X - 5X	INCREASED PRODUCT QUALITY (BY YIELD OF ACCEPTABLE PRODUCT)	CAE, CAM, CAQC
3X - 35X	INCREASED CAPABILITY OF ENGINEERS (MEASURED BY EXTENT AND DEPTH OF ANALYSIS (NUMBER OF DESIGN ITERATIONS) IN A GIVEN PERIOD OF TIME	CAE
40 - 70%	INCREASED PRODUCTIVITY OF PRODUCTION OPERATIONS	CAM, CAPC
2X - 3X	INCREASED PRODUCTIVITY OF CAPITAL EQUIPMENT	CAM, CAPC
30 - 60%	REDUCTION OF WORK IN PROCESS	CAPC
5 - 20%	REDUCTION OF PERSONNEL COSTS	CAE, CAM, CAQC, CAPC
20 - 60%	REDUCTION OF SCRAP/REPAIR	CAQC

Table 2: Savings Resulting from Concurrent Engineering

COMPANY	PROGRAM	SAVINGS
AEROJET	SADARM Subminitions	Reduced number of test stations required to manufacture product from 14 to 12 saved 340K
BOEING AEROSPACE CORP.	Ballistic Systems	Reduced labor rates by $28/hour Realized 16-50% cost reduction below bid 30% reduction in Part and Material Leadtimes 99% defect free operations
GTE	C3 Systems	25-30% reduction in cable harness assessment 60-90% increase in automatic insertion of components
LITTON DATA SYSTEMS	AN/TSQ 73	10% LSA savings attributed to elimination of dedicated typist for tech manuals
MCDONNEL DOUGLAS	Aircraft, Astronautics	60% savings on bid for reactor and missile projects 58% reduction in scrap 29% reduction in rework 70% reduction in defects 80% reduction in ECPS
NORTHROP	ATF	50% savings in time and direct cost to design, fabricate and inspect production tooling for header board assembly
	F/A-18	$20M projected savings over course of contract using paperless factory on final assembly
TEXAS INSTRUMENTS	Electronic Systems	50% reduction in recurring tool inventory cost
UNISYS	AN/AYK-14 STD Airbourne Computer	25% decrease in unit cost

MRP II) may interact with CITIS. Examples could be the ordering of replacements when minimum stock levels are reached. Cost savings will be realized through more efficient stocking of parts.

COSTS

What are some of the costs which will be associated with CALS implementation? Certainly there will be direct investment required in computing hardware and software to provide CITIS, but there will be other costs as well, both financial and psychological. New organizational structures will have to be evolved to optimally implement CALS, as well as CIM. New avenues of communication will open which require their own infrastructure.

An example of the implementation of CALS can be drawn from the B-2 program. Northrup implemented a highly integrated computer database which included the product definition, manufacturing and logistics information. The B-2 Program is the best example currently available of the implementation of CALS. Indeed, this was originally envisioned as a CIM implementation, because CALS did not yet exist. The system was built up as the program progressed through Demonstration/Validation and Full Scale Development. This steady progress allowed the first B-2 to be built using production tooling, rather than "soft" tooling which might be used for a prototype aircraft. The total investment for computing equipment, new machine tools, training and other capital investments was approximately one billion dollars. Subcontractors and the Government are now able to receive data and deliverables through a secure computer network. One of the advantages in this implementation, however, was that as data was generated it was immediately available in the required formats.

The fundamental problem with the implementation of CALS on legacy systems is that the data supporting those systems exists in many forms. These forms include, but are not limited to:

- Paper
- Aperture Cards
- Digital Files
- 2-Dimensional CAD Files
- 3-Dimensional CAD FIles
- APT Program Tapes.

Another feature of this problem is the lack of consistent configuration management techniques. This shows up in change order processing, changing documentation requirements as a program moves through its life-cycle and any technology transfers between manufactureres which have taken place.

Costs for CALS implementation on legacy systems will impact both government and contractor organizations. There will be costs associated with:

- Data Delivery
- Data Conversion
- Proposed Availability
- Acceptability.

Cost sharing arrangements will be needed for each of these four areas. Cost sharing proportions will almost certainly vary in each area, depending on the level of benefit for each party.

Data Delivery is the providing of data by the contractor to the Government for the purpose of CALS implementation. The costs in this area will vary from the preparation of tapes, to the searching of paper archives for previous deliverables. In order to proceed with the next step, Data Conversion, the information will have to be in proper format, clean and in usable condition. This is not a trivial problem, especially for systems which are in or past production.

Data Conversion is the process by which the delivered data is processed into a CALS or CITIS format. If the level of implementation is CITIS Level 1, then the problem is mainly one of cataloging the information and preparing a database of the catalog. The conversion aspect in this case is to make sure that data can indeed be delivered in paper form on demand. Higher levels of CITIS will require processing of images and text into an integrated database or databases. This may be accomplished by scanning, loading or other techniques. The cost, however, will steadily increase with increasing levels of CITIS.

Increasing levels of CITIS involve increasing the levels of availability. CITIS itself presupposes the costs of timesharing and data maintenance. Data Availability, however, will require increasing levels of utility of the data. The data will have to be manipulable as well as visible. This means at least raster if not vector images of designs. 3-D models of designs are probably most preferable, however it is unlikely they will be available on legacy systems.The greater the utility of the data, the greater the cost of implementation.

Pricing will be a major concern for CITIS. This pricing, since it will be an on-going cost to programs, must be considered in the overall implementation cost of CALS. CITIS is expected to be hosted by system prime contractors. Base annual fees and usage fees will be charged to the Government. What still remains an open question, however, is the Government portion of the initial investment and subsequent investments to make CITIS more accessable.

An area of cost which is to date virtually unaddressed is the cost of Acceptance. Acceptance is the willingness of contractors to provide the data and make use of it. Providing the data is more than merely tasking the contractor for another deliverable. Rather, it involves a decision on the contractor's part as to what he is willing to provide in the Technical Data Package (TDP) and how his proprietary data rights will be protected. If the information may be disseminated, then contractors will expect to be paid for the "damage" that the dissemination will cause to them. At the moment these costs are simply unkown.

The part of Acceptance involving use of the data is also a major concern. While it may well be in the interest of the contractor to improve his operations using digital data, this depends in part on the type of contract he is working under. Cost Plus contracts will require incentivization of the contractor to make changes. Even some Firm Fixed Price contracts may need modification. Improvement clearly has its price.

Returning to the B-2 case, if the program price is somewhere between \$ 50 and 100 Billion (based on estimates of both units and fully burdened unit costs), then this would indicate that the cost of implementing CALS from the ground up on this program consumed about 1 to 2 percent of the total program cost. Given the wide variety of formats and configuration control mechanisms extant in any legacy program, there is little reason to believe that a major CALS implementation could be performed for less than 1 to 2 percent of the program costs. This would also depend on the desired level of CITIS and age of the program.

BENEFIT/COST RATIO

Assessing the total dollar benefits of CALS on legacy systems is not a simple task. Certainly CE may result in up to 20% savings in design; this has been CE's history on other projects. This assumes, however, that there is a system modification or some other major design activity. CIM implementations have historically shown even greater benefits outside of the design arena. These improvements have often been close to 50%, for the particular area. CALS, in addition to the benefits of CIM, promises improvement in field activities will result in better productivity of maintenance and logistics personnel, as well as increased availability of systems.

Estimates of total life-cycle cost savings due to CALS have been around 25%. If standard assumptions are used about the break-out of acquisition versus support costs, then savings from CALS implementations could easily range from about 8% to 14% of system cost. Assuming a one to two percent cost of implementation, then the benefit to cost ratio would be at least 4 or 5 to 1. TASC research suggests that a figure of 6 to 1 will be more likely. The exact ratio will heavily depend on the position of the system in the life-cyle.

SUMMARY

The direction of DoD in the CALS arena is clearly set. CALS will become a reality. CITIS will be the first step in realizing this goal. CITIS' flexibility will play an important part in beginning the process of conversion from paper to an all digital acquisition and logistics environment. Each level of CITIS has associated with it particular costs and benefits to both the Government and the contractors.

Certainly in CIM implementations there have been many success stories. Currently there are many estimates being put forward on both the costs and the benefits CALS. However, since CALS encompasses broad areas of system support, unlike CIM, clear data on total costs and benefits awaits actual implementation projects on a broad scale.

The question of the benefits outweighing the costs has been verified anecdotally. Key in the implementation of CALS is the role which it will play with legacy systems. There will have to be multiple levels of CALS integration into the current stages of acquisition and logistics support of these systems. Achieving this, partly through CITIS, will require substantial investments from both the contractor and the Government. However, these investments will may be expected to provide at least a 4 to 1 return on investment.

END NOTES:

1/ This quote was extracted from MIL-HDBK-59A

2/ This table was developed from data presented at AUTOFACT '88

FROM TEAM TO TEAM: REVOLUTIONARY MANAGEMENT STRUCTURES IN THE NATIONAL AERO-SPACE PLANE PROGRAM, 1982-1990

Dr. Larry Schweikart
University of Dayton

ABSTRACT

The National Aerospace Plane (NASP) project represented a technological and financial challenge equal to that posed by the Panama Canal when measured in proportional terms. To build and test an X-30 aircraft that could achieve Mach 25 almost entirely on airbreathing propulsion, then shoot into orbit, while retaining airplane-like characteristics all before the 21st century constituted a task that could be met only through the most intense and innovative program since the Manhattan Project. Program management has strived for unique, even revolutionary ways to streamline management processes, enhance program support within and outside government, and push technology rapidly on a relatively low budget. As of 1990, those efforts had resulted in two management arrangements, essentially independent of each other, that are virtually unique in the history of American acquisition or research and development (R&D). One, an interagency/interservice agreement produced a team that sought to solidify support inside the government and the Armed Forces. The other, a multi-contractor agreement, committed five competitors to join in a team R&D effort that involved a full sharing of talent and knowledge and a complete pooling of resources.

Under the second team---the contractor team---innovative management continued. Not only did team formation include "product package" assignments but the structure of the National Program Office itself had to allow an innovative approach to the government's part, in that the government had become both team member and manager. That led to the use of a matrix management structure. The program's management cleared a major hurdle when the Acquisition Strategy Panel approved its strategy in September 1990.

INTRODUCTION

In the history of collective technological achievements that required innovative project management, two examples readily stand out: the Panama Canal and the Manhattan Project. Generally, students of acquisition or research and development (R&D) projects tend to ignore or downplay either or both accomplishments as useful roadmaps for normal peacetime approaches to management. After all, both represented (or, at least, were justified as) major projects undertaken in the context of national security.[1] The Manhattan Project---more the pure R&D project of the two---was clearly a wartime effort. Both programs incorporated unique, even radical, approaches to management and both required the cooperation of engineers, scientists, and administrators from both the military and civilian sectors, and from government and private industry alike. But the question remained, could such heroic and exceptional efforts, engendering similarly radical management approaches, occur in the modern peacetime environment? Had the government, military, and contractor bureaucracies grown so large and unwieldy as to dim hopes for remarkable programs and innovative management?

The National Aero-Space Plane (NASP) Program offers some answers to those questions. As currently chartered, NASP is a R&D program to demonstrate the technology to achieve orbit by using airbreathing (ramjet/scramjet) propulsion by building and flying two X-30 aircraft with the second airplane flying to orbit (see Fig. 1, "Artist Conception of the National Aero-Space Plane" and Fig. 2, "Blended Engine/Airframe Propulsion System").[2] It involves ensuring "aircraft like operations," meaning horizontal takeoff and landing on conventional runways, rapid turnaround, and manned control all captured under the key phrase single stage to orbit (SSTO). Flying at up to Mach 25 in the atmospheric envelope (see Fig. 3, "Trajectory Comparison"), the aircraft will encounter extreme heat on critical areas (see Fig. 4, "Artist Conception of Earlier Configuration Experiencing Heat Effect"). For maximum combustion to power the scramjet, the X-30 will use freezing cold liquid hydrogen (LH_2), which also serves nicely as an active cooling system pumped through the aircraft (see Fig. 5, "Active Cooling"). To meet the challenge of achieving SSTO, NASP will have to make corresponding revolutionary technological advances in at least five critical areas: propulsion, aerothermal, avionics, materials, and computational fluid dynamics (see Fig. 6, "NASP Technology Challenges"). The program's objectives not only included conducting research in the mode of earlier X-aircraft programs, but it borrowed heavily from rocket technology as well (see Fig. 7, "NASP Geneology"). The X-30 vehicle would demonstrate both SSTO and hypersonic cruise capability with airplane characteristics, as well as develop a technology base to enable operational follow-on "NASP-derived vehicles" (NDVs) that would reduce the cost of putting payloads in orbit by a factor of ten. As currently budgeted and scheduled, the first flight will occur in 1997, with SSTO flights demonstrated before the year 2000.

EARLY PROGRAM MANAGEMENT, 1981-1985: FORMING AN INTERSERVICE/INTERAGENCY TEAM

No individual had more of an impact on the shape of the program in its early days than Dr. Robert Williams, a program manager at the Defense Advanced Projects Agency (DARPA), who received a briefing by aerospace engineer Tony duPont in 1981. duPont convinced Williams that a hypersonic aircraft could achieve orbit; Williams convinced his superior, Dr. Robert Cooper, of the same idea. After low level research supported duPont's claim, Williams sought and received the go ahead for a larger DARPA study called Copper Canyon, initiated in 1984 based on the duPont design (see Fig. 8, "duPont Design"). Copper Canyon validated the concept of airbreathing, SSTO, and Williams proceeded to request a full scale project to test and validate specific technologies (Phase 2), culminating with a contract award originally scheduled for 1990 to build and test two X-30 vehicles.[3]

From the outset, Williams realized that achieving the necessary breakthroughs in multiple critical technologies would require a long term commitment to the program's funding and would demand the very best ideas of the entire aerospace community. Therefore, to solve the first problem he conceived a program arrangement that enlisted the participation (and, hence, dollars) of not only DARPA, but also other potential beneficiaries. That included, among the services, the Air Force and the U.S. Navy. The new Strategic Defense Initiative Office (SDIO) also had a need for easy and low cost access to space. Williams solicited the support of the National Aeronautics and Space Administration (NASA), where much of the essentiel expertise was available. Searching for a way to commit those players, Williams circulated a unique, five-way Memorandum of Understanding (MOU).[4] Each agency/service branch pledged funding, and, with the exception of SDIO, each also assigned personnel to the Joint Program Office (JPO) created by the agreement. Although in 1986 the JPO was located at Wright Patterson Air Force Base in Ohio, under the authority of a program manager (Brig. Gen. Kenneth Staten), Williams remained the overall project manager and DARPA made all the final decisions (see Fig. 9, "NASP Management Structure").[5]

A Steering Group comprised of high level DARPA, NASA, SDIO, Air Force, and Navy officials, as well as other experts on aerospace, defense, and science. The Steering Group advised and approved program direction, and served as a source of advocacy to the Congress and the Administration. While not entirely unique, the steering group added yet one more element to the image that NASP was different.

To address the second need---getting the best ideas of the entire aerospace community---the government let contracts to five airframe companies (Boeing, General Dynamics, Lockheed, McDonnell Douglas, Rockwell International) and two engine companies (General Electric and Pratt and Whitney).[6] Soon, Rocketdyne, a Rockwell subsidiary, offered to participate on its own funds and received a no cost contract, which constituted essentially admission to the game but allowed Rocketdyne access to all the jointly held knowledge and trade studies. Holding out the reward for the potential NDV contracts, as well as the Phase 3 contract to build and test X-30, the government hoped the intense competition between contractors would generate a useable design for the next phase. But the government also anticipated that it would benefit from the ideas and design innovations of all the companies. Ultimately, management thought, even after it selected a winner for the Phase 3 contract, the government anticipated that it could improve upon the overall design thanks to the broad knowledge it would acquire from all the contractors. The contractors also understood that merely by participating in the program they stood to gain in quantum terms a technology jump on non-participating competitors, particularly foreign competitors. Thus, even at an early stage of the program, everyone appreciated the importance of R&D spillovers within technology "vicinities."[7] Moreover, the contractors perceived that participation was crucial to keeping up with the technology, and they generally commented that the long term payoffs of the technology would far surpass the value of the contracts themselves.[8]

NASP, then, pursued a R&D goal through the mechanism of a competitive contract, funded by a multi-agency agreement administered by a DARPA director and run out of a project office staffed with Air Force, Navy, and NASA personnel. The program included seven competitors funded by government contracts and one contractor playing on its own money. Certainly this was no typical program!

Even the name, "National Aero-Space Plane," sought to bring a higher status to theprogram than merely another Air Force or NASA program. By playing on the "national" theme and the "team" concept, the X-30 program distinguished itself and thus often attracted special attention, which had both its positive and negative sides. In a positive sense, the DoD exempted NASP from the Defense Acquisition Board (DAB) process, which facilitated a much more streamlined approach. On the other hand, as NASP pushed aerospace technologies into uncharted areas, many experts expressed concern that the program had not assessed the risks fully or was optimistic about the availability of new materials. Those concerns led to special investigations by the Defense Science Board (1987) and the General Accounting Office (1988).[9] Although the former, a pessimistic report, proved damaging, it led to the creation of the Technology Maturation Plan (Tech Mat), a highly innovative plan to identify, isolate, and meet almost 1000 technological challenges that the program had to solve for success.[10] By virtually all assessments, Tech Mat emerged a resounding triumph, and by 1990 had established the crucial trade studies upon which the designs finally rested. Program management pointed out that by the time the Defense Science Board Report actually appeared publicly---almost a year and a half after its completion---many of the problems it identified had either already been solved or were being addressed by Tech Mat. In one of its first real management challenges, the program had simultaneously deflected any damaging effects from the Defense Science Board while creating an innovative vehicle for addressing technological hurdles in the future. The favorable General Accounting Office Report reflected the contributions Tech Mat had made.[11]

In 1987, after several scheduled reviews, the program pared off three contractors. Lockheed, Boeing and General Electric were downselected for a variety of reasons. Rocketdyne's design offered a different approach to those of General Electric and Pratt & Whitney. Robert Williams, wanting to keep as many different ideas alive as possible, noted that Rocketdyne met that objective.[12]

From 1986 to 1988, DARPA continued to manage the program while each participating service or agency contributed its own budget line. But the program had grown too big for a DARPA program. As Williams explained it, "if NASP took a [budget] hit, it could hurt our entire budget.[13] Wishing to relieve itself of NASP, DARPA transferred control of the program to the Air Force in early 1988. At that time, DoD also concentrated all budget lines under its jurisdiction, meaning that the contributions of the Navy, DARPA, and SDIO no longer appeared as separate amounts. Only NASA's contribution continued to receive a separate budget line.

In essence, the consolidation of the budget under Air Force authority marked the end of the *first team*, even though the Navy continued to assign an officer to serve as a director in the program. But SDIO had never had any personnel co-located at the JPO, and Williams had remained DARPA's only employee in NASP management. The consolidation meant that the Air Force and NASA remained the two primary participants, with a relatively small but significant direct involvement by the Navy. To some extent, Williams could claim a victory for his attempt to place the program above the internicene service battles and, by bringing in NASA, to insulate it also against charges that the X-30 had purely military applications. Even though that working relationship essentially ended when the Air Force took over the lead management role, and even though the national team concept never succeeded in protecting the program from budget attacks, the national team concept lived long enough to lay the groundwork for future efforts to use the "high road" to obtain budget support. It also endowed the program with the "national" tag in its name. That proved of little help in the early struggle for program support, if for no other reason than the program was too young to benefit from that title. Over time, however, public awareness of the program promised to grow, and could only profit by the connotation of the program as a national effort akin to the Apollo program. Developing the public perception of the program in those terms, rather than merely as another "X" series aircraft, constituted a major accomplishment.

MANAGEMENT REDIRECTION, 1988: FORMING A CONTRACTOR TEAM

When DARPA moved the program, Williams departed too. In November 1987, Gen. Staten had received a new assignment. His position as program manager at the JPO went to Dr. Robert Barthelemy, the head of the Air Force Wright Aeronautics Laboratory. From November until February, Williams attended to strategy as the program head in Washington; Barthelemy oversaw daily management activities from Dayton. When DoD transferred the program to the Air Force in February, it also shifted management control, and Barthelemy replaced Williams. Barthelemy continued to manage the technical direction of the program from Dayton.

Even at the outset of his tenure, Barthelemy thought that the program had fast approached the point of diminishing returns when it came to having multiple contractors work on the same problems. Competition had indeed produced wonderful breakthroughs, and had resulted in significant contractor investment into the program. By 1988, however, competition threatened to eat up scarce resources in duplication. Equally important, Barthelemy realized (and Williams had suspected) that no single contractor could solve all the technological problems alone. Each contractor, however, had made remarkable progress in different areas. Barthelemy looked for a way to combine their efforts rather than eliminate competitors as the original plan and schedule had called for. He had an interest in "Japanese-style" management, as he noted many times.[14] Internally, he tried to move the JPO toward more of a "consensus" approach to decision making. Externally, he saw a role for the Federal Government to play in at least shaping industrial policy.

Beltway budget politics added momentum to the notion that protracted competition might only erode the program's resources before it achieved breakthroughs in critical areas. The Air Force had attempted to drastically cut the NASP funding in two consecutive years, but the Secretary of Defense put the money back in the budget (at a reduced level than planned). Consistent support for the program had come from the top levels of the administration, with President Ronald Reagan publicly embracing the program in his state of the union message in which his speechwriters mislabeled the aerospace plane the "Orient Express."[15] Virtually everyone expected top level support to continue if George Bush won the 1988 election. But Bush, a former Yale baseball player, threw the program a curve ball when his newly named Secretary of Defense Richard Cheney recommended transferring the program entirely to NASA, and "zeroed" DoD funding for NASP. Program supporters convinced President Bush to let the decision on the X-30 rest in the hands of the recently created Space Council chaired by Vice President Dan Quayle.[16] The Space Council recommended continuing the technology development phase of the program but stretched out the schedule.[17] It increased overall funding, but reduced the funding on a per year basis. That reduced funding put still further pressure on an already tight budget. Dividing the scarce resources among five contractors offered a small chance for a major breakthrough and threatened to eat up the budget in redundant research.

A discussion of acquisition and competitive strategy developed out of the requirement for each airframer to prepare two different proposals (one for each engine design). One participant in the discussion observed that the JPO had acted like the X-30 airplane itself was the reward for the contractors. According to the original schedule and plan, the government was to select a single contractor each for the airframe and propulsion and eliminate the rest. In so doing however, the JPO might well exclude other airframers and engine contractors from competing for the contracts to build NDVs, where the government really wanted competition, because the potential level of funds laid out for NDVs would substantially exceed the outlays for the X-30 (assuming that the X-30 indeed demonstrated SSTO technology).

Barthelemy, too, gave consideration to forming all the contractors into a team. Legal hurdles existed, and the situation lacked precedent in other programs. But he urged the contractors to consider the possibility. Moreover, a precedent existed within the program: in 1987, realizing that all five contractors needed the same exotic materials and unique composites, the JPO formed the materials consortium (officially called the NASP Materials and Structures Augmentation Program, or NASP ASAP). The program pooled the FY 1988 $150 million augmented materials funds among the five contractors, while the Tech Mat materials funding continued in parallel. Robert Gulcher of Rockwell and Hershel Sams of McDonnell Douglas spearheaded the formation of the consortium. They and the other contractor leaders forged an agreement through an associate contractor arrangement that allowed the team to avoid antitrust laws. Under the consortium arrangement, each contractor took the lead in a key class of materials. The contractor took orders for the overall quantity required from everyone and placed a single large order with one set of specifications agreed upon by the contractors. Howard Wright, who served as the NASA principal deputy at the JPO for several years, compared the process to MITI's approach of identifying problems and forming industrial teams to solve them. It has worked like a charm, and most observers considered the consortium an unqualified success. Another consortium, on subsystems, was planned at the time that the contractors formed the team in 1990.

Teaming gained further impetus during the summer of 1988. At the June Steering Group meeting, Dr. Robert B. Costello, the Undersecretary of Defense for Acquisition, who served as the Steering Group Chairman, opened the meeting by suggesting that the issue of competition needed careful examination. He emphasized that the zero-sum competition constituted an inefficient use of resources. Costello noted that the various designs had started to converge, and as a result of Costello's urging, the JPO agreed to develop options for restructuring the program, complete with an estimate of cost and risk. Barthelemy, if he ever harbored any doubts about teaming, quickly dispelled them. He embarked on a campaign to lead the contractors to some type of voluntary teaming arrangement. Unfortunately, many contractors interpreted his efforts at teaming as his own individual preference, not a statement of government policy. Nevertheless, they took the position that they favored teaming in principle. Their individual views greatly depended on the nature of the specific arrangement and where they perceived they stood in the overall competition. Nevertheless, by Autumn 1988, teaming grew ever more likely.

It requires a brief digression to put the events of 1988-1990 in the perspective of a substantial body of research on competition in defense programs. The benefits of competition vs. sole source suppliers is not as conclusive as many might think. Proponents of competition in the civilian sector, such as Michael Porter, have perceived no benefits to any arrangement that reduced competition, even under the auspices of strengthening competition against foreign competitors. He noted that "market sharing, informal agreements, or widespread cooperation can turn a group of aggressive rivals into a club."[18] Jacques Gansler, in a study of three types of teaming arrangements, multi-service, international, or industrial, concluded that management approaches used on those programs historically have been unsuccessful in achieving the promised economic advantages.[19] A GAO report, which defined a successful joint program as "one which brought about a substantial harmonization in fielded systems, satisfied participating services, and realized actual savings," concluded "no success [has] been achieved so far."[20] TASC conducted s study of 80 multi-service programs and 50 single service programs that found "greater funding turbulence, difficulties of resolving technical requirements, difficulties of staffing the organizations, different priorities, lack of commitments on one part or the other, and significantly different business practices" in joint programs.[21] Teaming in the Airborne Self Protection Jammer (ASPJ), co-developed by ITT and Westinghouse, witnessed a cost increase that exceeded original estimates by a factor of two, and the development was more than two and a half years behind schedule.[22]

Yet evidence does not make a clear case for competition in defense programs, either. Michael Beltrano's study of the Sparrow AIM-7F missile showed that "the dual-source competition actually lost money; that is, the total recurring price for the two producers . . .[was] 13 percent higher than it would have been if the initial source, Raytheon, had produced the entire quantity . . . ."[23] In the highly competitive ship repair business, of 75 fixed price contracts investigated by the General Accounting Office, all 75 cost more than contract price by an average of 63 percent.[24] And the case of ElectricBoat and Newport News in submarine construction suggested that competition carried few advantages: when government froze Electric Boat's contracts for Los Angeles class submarines in 1981 because of cost disputes, Newport News immediately raised its bid prices for the three submarines it planned to deliver that year. When Electric Boat reentered competition, prices remained at the raised levels set by Newport News.[25] Finally, from a historical perspective, teaming arrangements have proved less than satisfactory. In 1938, when a military board recommended having competitors submit several promising designs, followed by government funding of the development of an experimental aircraft, followed by a competition (a "flyoff"), Congress and the services displayed their reluctance "to pay for the development of sample aircraft knowing full well that one or two of the samples under development would be cast aside during the final competition."[26]

That was exactly what NASP management wanted to avoid---developing six design combinations, each of which had weaknesses---instead of one composite that brought together the best design ideas of all the contractors. Moreover, unlike other programs studied, NASP constituted an R&D project, not an operational effort. Even Gansler and Porter concluded that teaming could provide advantages under the right conditions. First, Gansler contended that the "schedule and funding . . . be fixed, and decisions related to management of the program delegated to a single joint program office," which was the case with NASP from 1988 to 1990 when the contractor team established an office (called the NPO or National Program Office).[27] After that time, the chain of command continued to remain well defined. Second, while Gansler warned that "once the [contract] award is made to a team, even though two or more prime contractors are involved, competition has been effectively eliminated," in the case of NASP, management determined that to get to the state where it had competition for the more expensive part of the program, the many NDVs that would follow a successful Phase 3, the contractors had to team in the R&D phase.[28] Without spreading the hypersonic knowledge base around, the barriers to entry for NDVs would exclude all but the final Phase 3 contractor.

Porter observed that such cooperative research could prove beneficial if it met certain conditions.[29] First, research needed to occur in areas of basic products and processes or to catch up to the state of the art, but not in the firms' proprietary sources of advantage. NASP, while certainly not aimed at catching up to the state of the art, was not research focused in any company's area of proprietary advantage. Second, cooperative efforts, should, according to Porter, constitute only a modest portion of firms' overall research. In the case of NASP, no contractor put up more than 9 percent of its total R&D budget, and most put in far less. Third, cooperative research needed to take place through a separate, independent entity, to which the majority of industry participants had complete access, which aptly described NASP. A fourth criteria established by Porter required that only R&D needing a substantial investment and yet impinging on a number of industries stood to benefit from a cooperative effort. NASP fit well in that definition. Finally, Porter contended that all cooperative R&D should include a number of firms involved in active rivalry rather than be restricted to a few dominant or favored firms. That condition, too, applied to NASP. Thus, across the board, NASP fit the criteria of a cooperative R&D program that promises to benefit the competition advantage of the participants.

Such was the theoretical background behind joint ventures and teams. On October 22, 1989, the JPO attempted to put the theory into practice when it generated a Request for Proposal to all the contractors that they could only satisfy with a teaming arrangement. Between November and the end of December, the contractors met to try to arrange a voluntary team before the government forced it on them. The Undersecretary of Defense for Acquisition, John Betti, and Deputy Administrator of NASA, J.R. Thompson, had given their approval to the formation of a contractor team, but under what the contractors thought might be less than desireable circumstances. Consequently on January 22, the CEOs of the 5 contractors met to formalize and sign the teaming documents that the legal staffs had prepared. They asked Barthelemy for his recommendation for contractor program manager, and he suggested Barry

Waldman of Rocketdyne, who, in order to accept the position and also to meet the unstated but understood requirement that an airframe company and not an engine company lead the team, would agree to leave Rocketdyne and to move to the corporate level at Rockwell.[30] Waldman thus took over as the contractor program director and Rockwell became the lead company. Exactly how the team members' workload would be divided was left to the contractor program manager subject to JPO approval.

Anticipating quick government approval of the team, Waldman and his advisors distributed a plan for implementing the team. One challenge involved dispersing information in a non-evaluative setting. Each contractor had to share his data with the others, but management wanted the contractors to remain open to the ideas of their former competitors. To facilitate an atmosphere of trust, Waldman involved participants from all the contractors in an Ad Hoc staff.

Before much else could happen, the team needed official approval from the Assistant Secretary of the Air Force, John Welch, and from Betti. Everyone expected approval to come by February 15, and much of the schedule had rested on the assumption of a positive decision by that date. Welch did not give his approval then. Without official sanction, the contractors could not co-locate personnel or exchange technical data. The momentum the program had built up started to slip away. During the delay, Barthelemy, Waldman, and JPO directors started to refine the program philosophy so that everyone agreed on the objectives. Those objectives included establishing the technology and data base for fully capable NDVs, including propulsion, materials, aerothermodynamics, and analysis and ground test. In addition, the X-30 needed to demonstrate the technology for SSTO; establish the technology and data base for hypersonic flight (including the development required for SSTO capability); and to demonstrate the technology for hypersonic flight.[31] Although the program emphasized research, it contained a commitment to make the data applicable for fully-capable NDVs.

The government had prepared to adopt a new style of management. It recognized the need for a new JPO management approach that encouraged team behavior. A new contractor/management relationship also needed to emerge in which the government adapted to its dual role as participant and manager. Government directors were team members, not just evaluators. That new role developed in part because the government had expertise that no single contractor had. But the dual management/participant role required an innovative structure to prevent friction with the contractors.

On May 17, Welch gave his approval, and Betti folowed a few days later. Objections that the team may have violated antitrust laws disappeared as the most ambitious corporate teaming arrangement in American history had become a reality. Three weeks earlier, in anticipation of the approval, the JPO created the National Program Office (NPO), which it located at Seal Beach, California. The JPO team organization had the NPO report to the JPO, and a contractor CEO Steering Committee advised the NPO, which had control over the new office (see Fig. 10, "National Aero-Space Plane Team, 1990"). As for the NPO's organization, it had six directorates that reported directly to Waldman, with each of the six directorates parceled out among the contractors for political balance, although each candidate had to be technically competent and acceptable to the program manager (see Fig. 11, "NASP NPO Organization, 1990").[32]

Following the approval by Betti and Welch, the NPO organized quickly to try to recapture some of its lost schedule. The contractors met from June 11-15 to have a "data dump" among themselves. To avoid an air of judgmentalism, the contractors met without any government managers present at what they later called the "open kimona." It was hard enough to admit to your competitors your failures---as well as your successes---without the presence of the government, which knew all the contractors' programs intimately. Waldman wanted to focus all the activities in a positive manner. He therefore split the contractor personnel into technical teams and directed them to dig deeper into the technology by focusing on delivering carefully defined product packages. That prevented the contractors from emphasizing past processes ("we did it this way at GD"), and it provided an overall roadmap as to exactly how the NPO planned to take over program management. While they pursued those tasks, Waldman kept moving the teams around to each contractor's home facility to head off any charges of partisanship. Indeed, he concluded from the outset that he needed to emphasize all aspects of team building, whether from exercises, social arrangements, workloads, or any other aspect, if the team concept was to succeed.[33]

A non-judgmental approach proved essential to forging a team identity. The NPO could not have the engineers sniping at each other about which company had the "right" idea. Instead, the NPO tried to focus the teams forward, on new trade studies with the ideas of all the members. In the case of the structures group, a tremendous success story developed. When the members met, they found that their "weight guys" had different estimates. Waldman asked them to go back to their "home company" designs and track the weights as a group to determine if, and where, the "weight guys" had erred.[34] Seeing the potential for divisiveness, the group instead offered to refine existing estimates through new trade studies. That allowed them to work out their differences on a new design as it emerged, rather then battle over the "causes" of errors (really different ways of interpreting data) that had crept in to the program. According to Waldman, that "unboxed the engineers," turning them loose to resolve things going forward that they never would have resolved looking backward.[35]

The rapidity with which the new team flew into action masked the complexity of the teaming arrangement, especially the details to which the government had to attend. For example, simply modifying the existing contracts to allow teaming (called the "2C" contracts) had to occur while the JPO and NPO prepared to present their acquisition plan to the Acquisition Strategy Panel in September. The contractors delivered their final Phase 2C contracts by August, and the engineer teams worked to reach a composite configuration of their designs ready by October. The JPO made that design public in late October at the annual meeting of the American Institute of Aeronautics and Astronautics (see Fig. 12, "Artist Conception of Composite Design"). Following actual teaming formation, the program faced its first hurdle, and the first real test of how well the team worked, in September when it had to brief the Acquisition Strategy Panel. The Panel approved the team acquisition strategy (known as Phase 2D). From that point on, the program's technical objectives included validating the technology to support vehicle design; fulfilling all exit criteria tasks; evolving a credible vehicle design; and developing the system and air vehicles' specifications.

A key feature of the team was that the fee was distributed equally. The two engine contractors would divide the engine fee and the three airframers would share the aiframe fee. Rockwell stood to receive a special award fee for its quality of support as lead company. More important than the award, however, all the participants stood to gain the most advanced ideas in hypersonics available. They would have a huge advantage over non-participating foreign <u>or</u> domestic companies.

All of that required a single contract in the form of a letter contract---another unusual characteristic. A letter contract would allow the NPO to manage the team immediately and would integrate technical activity in all respects. Moreover, a letter contract promised to continue the program's momentum. The Acquisition Strategy Panel agreed, and all elements of the program, including completion of the program plan, work distribution, the teaming agreement, and the letter contract, were scheduled for completion in January 1991.

One final gray area regarding the government's role remained. As "management before teaming," the government oversaw the activities of the contractors, meshing their data and discoveries as well as supervising their work. Yet through the NASA centers at Ames, Langley, and Dryden, the government also performed work in the program. With team formation, the government not only became the manager of the team, but it became part of the team work force, too. How would the government evaluate itself? How would the contractor manage the government? Several complicated questions lurked in the background. Again, the JP/NPO devised a system of matrix management common to the Air Force projects (see Fig. 13, "NASP National Team Organization Concept"). Typically, maintenance personnel are not assigned to, say, the B-1 bombers or the F-16 fighter, but rather personnel worked a function for all aircraft, such as landing gear, propulsion, and so on. That concept adapted well to NASP and the NPO, where, instead of government program directors who oversaw a contractor's work (say, the GD program manager at the JPO), the NPO divided the work on the basis of function. GD might have responsibility for fuel tank design and fabrication, as well as avionics. Thus the GD program manager would oversee all of GD's work, while a government director would have responsibility for all contractors working on related tasks, say, all those working the active cooling. Government team member units, fulfilling particular functions or supplying specific products under the direction of the government centers (directed by NAF), would thus report up the chain of command to the NPO through government directors as part of the "contractor team." Meanwhile, NAE, NA-1, and NAP directors would manage, and evaluate the entire combined lines of contractor and government activities. So while the government team units reported up to the NPO through NAF, their activities in conjunction with contractor activities would be evaluated under a work element managed by one of the government directors from NAE, NA-1, or NAP. In short, NASP insightfully adapted a well known arrangement to a unique situation to produce a management system well-tailored to NASP.

CONCLUSION: THE VERDICT OF THE ACQUISITION STRATEGY PANEL AND BEYOND

The favorable response by the Acquistion Strategy Panel and the successful attainment of a configuration in the Fall of 1990 marked milestones for the X-30 program and, at least in the short run, vindicated Barthelemy's vision and Waldman's strategy. Still a long way from an actual production decision, and an even longer way from flight, the program had evolved from one team to another. Each addressed a specific challenge, one political the other technical, and each benefitted from innovative approaches by management.

In the long run, only a successful orbital flight will satisfy some of the program's critics. To them, an operational aircraft represents the only justification for a program---even an X-aircraft. Yet the NASP has already pushed the technology in hypersonics, especialy computional fluid dynamics, materials, and propulsion, to new dimensions (Capt. Kirk might say, "where no man had gone before"). The ever adaptive and evolutionary management structure has made much of that progress possible. Indeed, NASP management initiatives---Tech Mat, the five way MOUs, the "national team," the materials consortium, and the contractor team---themselves have proved as exceptional as the revolutionary aircraft they manage.

NOTES

1/ On the Panama Canal, see David McCullogh, The Path Between the Seas: the Creation of the Panama Canal (New York: Simon and Schuster, 1977). The best description of the Manhattan Project is Richard Rhodes, The Making of the Atomic Bomb (New York: Simon & Schuster, 1986).

2/ The best work on hypersonics up through the early stages of NASP appears in Richard P. Hallion, ed. The Hypersonic Revolution; vol. II: Eight Case Studies in the History of Hypersonic Technology from Scramjet to the National Aero-Space Plane (Dayton, OH: Special Staff Office, Aeronautical Systems Division, Wright Patterson Air Force Base, 1987). Background appears in Robert Williams, "Forces for Change and the Future of Hypersonic Flight in the 21st Century," address before the First International Conference on Hypersonic Flight in the 12st Century, September 20-23, 1988, Ground Forks, North Dakota, available through DARPA; Larry Schweikart, "Contractor Investment and Program Management Lessons from the Trident Submarine and National Aerospace Plane Programs, 1972-1989," unpublished paper presented at the Triangle Universities Securities Seminar, February 1990, Duke University, (approved for public release by AFSC/PA December 5, 1989, ASD Case #89-2775); Jo Anne Rumple, "Computers 'lift' X-30 Into Space," Wright Patterson Air Force Base Skywriter, March 24, 1989; Col. Theodore Wierzbanowski and Terry D. Kasten, "Manned Versus Unmanned: the Implications for NASP," paper presented at the AIAA Second International Aerospace Planes Conference, October 29-31, 1990; William Piland, "Technology Challenges for the National Aero-Space Plane," presented to the 38th International Astronautical Congress, International Astronautical Federation, Brighton, United Kingdom, October 14, 1987. Other information came from interviews with Tom Cornell, Boeing, August 29, 1989; Carl Sypneiwski, Pratt & Whitney, October 9, 1989; Frank Capuccio, Lockheed, July 12, 1989; Fred Pinemann, Rocketdyne, July 12, 1989;

Curl Wiler, Rockwell International, July 11, 1989; Fred Kelley, General Dynamics, July 6, 1989; Gen. Kenneth Staten, July 17, 1989; Col. Vincent Rausch, July 18, 1989; Herschel Sams, McDonnell Douglas, July 10, 1989; Frank Boensch, NASP JPO, August 17 and various dates, 1989; Howard Wright, NASP JPO, May 31, 1989; Tom Donahue, General Electric, July 5, 1989; Lt. Col. Rodney Earhart, October 12, 1989; Lt. Col. Ken Griffen, October 10, 1989; Col. Ted Wierzbanowski, various dates, 1989; Major Dennis Miner, October 17, 1989; Major Scott Parks, October 31, 1989.

3/ See Wierzbanowski and Kasten, "Manned Versus Unmanned," passim.

4/ Information came from interviews with Robert Williams, July 18, 1989, and various dates by phone; Schweikart, "Contractor Investment and Program Management Lessons," p. 10.

5/ Interview with Gen. Kenneth Staten, July 17, 1989.

6/ Material on the early contract work comes from interviews with Williams, Cornell, Staten, Donahue, Sams, Rausch, Kelly, Capuccio, and Sypneiwski.

7/ Material on R&D spillovers is extensive. Among the many works by scholars, a few include Nathan Rosenberg, "Science, Invention, and Economic Growth," The Economic Journal, March 1974, pp. 90-108; Adam B. Jaffe, "Demand and Supply Influences in R&D Intensity and Productivity Growth," Review of Economics and Statistics, August 1988, pp. 431-437, and his "Technology Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value," American Economic Review, 76, December 1986, pp. 984-1001; Joseph W. Lee, "The Importance of Technology Transfer from Government Laboratories to Industry," Program Manager, September-October 1990, p. 23; R.J. Terleckyj, Effects of R&D on the Productivity Growth of Industries: An Exploratory Study (Washington, D.C.: National Planning Association, 1974); Jeffrey I. Bernstein and M. Isaq Nadiri, "Interindustry R&D Spillovers, Rates of Return, and Production in High-Tech Industries," National Bureau of Economic Research Working Paper #2554, April 1988; Timothy F. Bresnahan, "Measuring the Spillovers from Technical Advance: Mainframe Computers in Finance Services," American Economic Review, 76, September 1986, pp. 742-755; Zvi Griliches, "Issues in Assessing the Contribution of Research and Development to Productivity Growth," Bell Journal of Economics, 10, Spring 1979, pp. 92-116; Chase Econometrics Associates, Inc., "The Economic Impact of NASA R&D Spending," Bala Cynwyd, PA: Chase Econometrics, 1975; Herman C. Quirmbach, "The Diffusion of New Technology and the Market for an Innovation," RAND Journal of Economics, 17, Spring 1986, pp. 33-47; Jennifer Reinganum, "Market Structure and the Diffusion of New Technology," Ibid., 12, 1981, pp. 618-624, and her "Dynamic Games of Innovation," Journal of Economic Theory, 25, 1981, pp. 21-41; and Edwin Mansfield, "How Rapidly Does New Industrial Technology Leak Out?" Journal of Industrial Economics, 34, December 1985, pp. 217-223.

8/ Interviews with contractor personnel cited in note 2, as well as Barry J. Waldman and Tom Harsha, NPO, various dates, August 1990.

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RESEARCH, REFORMS, and TRENDS in ACQUISITION

THE MANAGEMENT OF EVOLUTIONARY ACQUISITION

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ABSTRACT

The concept of Evolutionary Acquisition has been actively advocated and debated for more than a decade now. To its proponents, its adoption has been bewilderingly slow to occur and, when it has occurred, these efforts have often been mismanaged.

This paper identifies and explores the major reasons for this situation; identifies the necessary components of a plan of action to address existing problems; and discusses the key tools required to support the management of an evolutionary acquisition.

INTRODUCTION

The concept of Evolutionary Acquisition (EA) has been actively advocated and debated for more than a decade now. To its proponents, its adoption has been bewilderingly slow to occur and, when it has occurred, these efforts have often been mismanaged or been otherwise disappointing.

This paper begins by identifying and discussing the validity of the major reasons that have been offered to explain the lack of progress experienced to date in the adoption of Evolutionary Acquisition. The existing impediments to a widespread adoption, and then successful application of Evolutionary Acquisition, are then identified and discussed. Experience with the introduction of Evolutionary Acquisition is then compared to the introduction of other new ideas or products. Known conditions for success in the introduction of change in individuals, groups and organizations are related to the current status of Evolutionary Acquisition and obstacles or impediments to further progress are identified. The outlines of an appropriate plan of action are presented. A key ingredient deemed necessary for the successful application of Evolutionary Acquisition is identified and discussed.

REASONS FOR LACK OF PROGRESS: REAL AND IMAGINED

In searching for reasons for the cautious move to EA, several theories have been advanced. It has often been suggested that large bureaucratic organizations are simply slow to change, that indeed people are slow to change. This observation is not new. Machiavelli observed that "There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things." Others have observed that while the traditional acquisition approach has indeed resulted in many disappointments and sometimes outright failures, that no one is held accountable or responsible. That doing things in the "traditional" way shields the individuals involved from any criticism. Some have either questioned industry's motivation by observing that more money is made on failures then on successes or have questioned program managers' motivations observing that bigger projects are more important. Still others argue that the case for EA has not been proven or that the necessary details to easily implement EA have not been worked out and provided to program managers.

Each of these observations has validity in varying degrees. Unfortunately, these observations are not expressed in particularly helpful ways. There are some common threads that seem to link these largely symptomatic observations and suggest a plan of action that should not only hasten the adoption of EA in appropriate cases but help to enhance their probability of success. First, despite what may seem like a great deal of talk about EA over the years, it is clear that, to many individuals in key positions, EA is a misunderstood buzz word. Second, implementing EA requires modifying, sometimes significantly, the way things are done in every part of the design and acquisition process. Just knowing that modifications are necessary to make EA work is not sufficient to ensure success. Rather a clearly defined and understood set of step by step procedures needs to be made available. Third, suitable tools capable of supporting an EA need to be made available.

NECESSARY CONDITIONS FOR PROGRESS

Progress, in this case, has two dimensions; first, that a higher percentage of appropriate programs utilize EA, and second, that those programs that utilize EA are better (more appropriately) managed.

In order to facilitate progress, the existing barriers first must be identified and removed. In the case of the first dimension, to increase the utilization rate of EA, one can start by looking at the different reasons that projects that should utilize EA often do not. Among the most important of these reasons are: 1) a rejection of EA as a valid and appropriate approach by a key decision maker involved in the project; 2) a project manager thinking that EA is being used, when in fact it is not; and 3) a fear of proceeding with EA without explicit permission and/or procedures.

The first two of these reasons (rejection of EA as a valid approach and thinking one is using EA when, in fact, it is not being used) relate directly to the first thread identified above: the lack of understanding of what EA really is on the part of key players in the process. These include individuals at all levels and in each of the organizations that are necessary to bring a program to fruition. These organizations include those responsible for establishing system requirements, representing the system user(s), managing the acquisition technically and contractually, and conducting quality assurance and acceptance and operational tests.

The third reason, which involves a fear to be either proactive or innovative, is related to the second and third threads identified above, the lack of precedence, procedures and supporting tools.

Essentially, what we are currently experiencing with the introduction of EA is a scenario that seems to occur in many different social, scientific and artistic milieu related to innovation, and community acceptance and change. The lessons learned in these areas may well be usefully applied in this case. Thus, a brief exploration of the underlying process and attributes of innovation and change effectuation is in order.

THE PROCESS OF PROGRESS

Progress comes in distinct stages from experimentation to widespread adoption and acceptance. Both the initial and final stages involve increasing dissatisfaction and the desire to improve the status quo, thus nurturing the seeds of progress and forming a never ending cycle. The way in which the scenario usually unfolds is surprisingly invariant over a wide spectrum of phenomena. It begins with dissatisfaction. The dissatisfaction with the current way of doing things spurs efforts to develop new approaches. Ideas of varying degrees of merit are formulated and are exchanged among an often widely scattered group of researchers and innovators. Papers are presented at conferences, symposia and workshops. Experiments are undertaken and reported on. Modifications are made to the concepts; more experiments are conducted and reported on. This phase of the process continues until there is a significant body of individuals in positions of influence that are convinced that the new approach is both desirable and practical. Then the process of institutionalization begins.

INSTITUTIONALIZATION OF CHANGE

Moving from a situation of scattered enlightened application by the most innovative practitioners to the adoption of the new method as business as usual, is a process that requires the involvement of a new set of players and different methods of promulgation than those that have been instrumental in developing and experimenting with new ideas and refining the new idea or product so that it is ready to be adopted for widespread dissemination.

This new set of players' views toward risk and job responsibilities usually differ somewhat from those involved up to this point in the process. While there is a wide range of individual propensities or tolerances for risk, and a similarly wide range of attitudes toward change and views of job responsibilities, there are also organizational and institutional considerations and constraints that serve to reinforce or moderate these individual preferences.

Normally, to rise through the ranks of any organization, an individual must adapt or modify behavior to be consistent with what the position and the environment demand. It should also be noted that there is also a process of self-selection at work, in that individuals tend to seek and be successful in jobs that require views and skills most closely aligned to their own. If one considers that to reach the more senior positions in an organization, often a circuitous route is involved, in which the individual passes through a wide variety of assignments, each calling for a different set of views. Then it must be concluded that either individuals in senior positions are capable of adapting their views to the requirements of the job or that, given the relatively few jobs that demand a strong risk taker or innovator, that these jobs are not on the usual career path to many of the senior positions.

The larger the organization, the more senior the positions involved, the greater the number of organizations that need to participate in the process, the greater the difficultly in institutionalizing change. When multiple organizations are involved, and there is no clear and effective point of authority, the decision process operates in the consensus mode. This process is very often paced by the most conservative of the participants. Even when only one organization is involved, its size or management style may result in the adoption of the consensus process.

Thus, it should be apparent from the above description of the individual and organizational environment which exists, that to achieve the desired result requires a good deal of energy and perseverance.

Institutionalizing change has two distinct phases. The first involves the official adoption of the new approach, policy or procedure. The second involves the adoption in fact by the organization, or organizations, necessary to implement the new approach. The first phase requires the "conversion" of the key decision maker(s) while the second requires the cooperation of what is often called "the bureaucracy." Obtaining the cooperation of "the bureaucracy" is often a painfully slow and arduous process, one that requires a prolonged and concerted effort in order to succeed. This is for several reasons. For one, many more people need to be educated and convinced. In additional, key decision makers tend not to be "on the job" for the duration, but only for a relatively short time. They tend to want to make their mark before moving on. Adopting a new approach to a vexing problem can be very attractive. Cynics would note that it is particularly attractive since these decision makers are unlikely to be around if and when things go wrong, having moved on.

The remainder of this paper will be devoted to taking a look at where EA is in this process of institutionalization and what steps are required to facilitate the institutionalization of EA and to enhance the effectiveness of EA projects.

THE STATUS OF EVOLUTIONARY ACQUISITION

Evolutionary Acquisition is clearly in process of institutionalization, somewhere between the first and second phases. EA has been adopted by some, but not all major system acquisition organizations, as a matter of policy. However, the policy statements have tended to be vague rather than definitive; permissive rather than directive. In other, words EA is currently being allowed, even suggested, but generally it is not being mandated. Without a strong mandate, EA will not easily be able to overcome the considerable inertia of the bureaucracy.

COMPLETING THE INSTITUTIONALIZING OF EA

In order to accelerate the institutionalization process for EA, a two pronged effort is needed to strengthen the mandate (top/down) and lessen the obstacles to implementation (bottom/up). The first prong needs to be designed to inform key decision makers regarding EA and the experience with EA to date and to revise appropriate policy and guidance directives. The second prong needs to identify, provide, and develop, if necessary, the procedures and tools needed to help make EA a less risky and more successful experience. Project managers need to be made aware of these procedures and tools and educated in their use.

THE FIRST PRONG: EDUCATING KEY DECISION MAKERS AND STRENGTHENING POLICY DIRECTIVES

The education of key decision makers is a continuing requirement due to the relatively high rate of attrition. In the absence of any organized EA missionaries, new decision makers are not systematically being identified and provided with the necessary information about EA.

While some decision makers will be convinced based upon their face of validity of the arguments for the use of EA, most will need to be shown appropriate empirical evidence that supports the claims of the proponents of EA. Therefore, emphasis needs to be placed on an effort aimed at collecting and distilling experiences with EA (both its successes and failures and the circumstances surrounding both sets of experiences). In addition, the seminal material about EA and its application needs to be updated and republished.

The relevant policy directives needed to be reviewed and updated to more effectively achieve the desired result. It has been shown that merely to provide permission to "tailor" procedures or to "deviate" from some norm are not very effective means of supporting a new approach. The policy directives that need to be reviewed include those that govern both the requirements and acquisition process as well as the testing process.

THE SECOND PRONG: PROCEDURES AND TOOLS

Current procedures and tools still reflect assumptions associated with the "traditional" acquisition process. These procedures, along with the tools that support them, include the full spectrum of activities that comprise a program's life cycle beginning with program planning and budgeting. The current planning and budgeting process needs to be modified to fully accommodate projects utilizing EA. This involves a restructuring of the funding envelope and the nature and timing of "go/no go" decisions.

COST MODEL: KEY EA TOOL

Of all the project management tools employed, the selection and use of a cost model has the greatest impact on the health of a project. The importance of realistic cost and schedule estimates cannot be over emphasized. Estimates that significantly underestimate either a project's schedule or cost have a domino effect that cascades throughout the life of a project, causing the project to be whipsawed from one crisis to the next.

Cost/time to completion estimates are equally important since, if accurate, they can "correct" a situation and help get a project back on track. Conversely, if inaccurate, they can exacerbate an already bad situation.

The selection of an appropriate cost model and its proper use therefore becomes critical. Many existing models that have been in use for some time are simply inappropriate for use with EA projects. In selecting a model, one needs to carefully consider the model requirements identified below in addition to those normally considered in all cost estimating efforts.

First, a model needs to account for the structural differences in the nature and flow of work that makes EA projects different from traditional projects. Of particular importance is that the model must recognize the impact that rapid prototyping and the fielding of a CORE system have on staffing, testing and scheduling.

Second, the model must bε able to both utilize information that is likely to be available at the early stages of the life cycle and be able to accept and utilize additional information as it becomes available. The information that is likely to be available at this time would be a fairly detailed concept of CORE capabilities but only a very rough idea of subsequent enhancements.

Third, the model must be able to revise its cost and schedule estimates during the course of the project based upon a) changes in requirements/capabilities, b) actual cost/schedule experience and c) the quality of interim products.

SUMMARY

In summary, Evolutionary Acquisition appears to be lingering in the early stages of the institutionalization process. To accelerate progress, actions need to be undertaken in a number of key areas. Among the most important of these are 1) the continuing education of decision makers regarding the nature of EA and its application, 2) the revision of relevant policies and procedures to facilitate the use of Evolutionary Acquisition, and 3) the selection and proper use of a cost model that has the capabilities needed to support the management of an Evolutionary Acquisition.

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PROACTIVE COST AND SCHEDULE CONTROL FOR THE NINETIES

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ABSTRACT

Acquisition in the decade of the nineties will be characterized by rigorous budget constraints and by requirements for programs to meet performance goals within delineated cost and schedule boundaries. Extrapolating present acquisition practices into the coming decade will not suffice to meet the new environment. Calls for substantial acquisition reforms and streamlining have abounded in recent years, and the general concensus of the community appears to acknowledge the necessity and inevitability of reform. The salient question which we members of the acquisition community must answer is: How do we re-design and tailor acquisition practices to meet the exigencies of the new environment?

This paper will examine one facet of acquisition reform, namely, how can program cost and schedule control be implemented in a more effective and proactive mode than has previously characterized defense acquisition? In addressing this issue, we will review current practices and assess their theoretical utility and their actual level of implementation success. Suggestions for refinements in theoretical foundations as well as in implementation practice will be made. These suggestions for timely augmentations and improvements to the present Cost/Schedule Control System (C/SCS) should be viewed as evolutionary embellishments to the fundamentally sound C/SCS principles. With further study and elucidation of cost and schedule control techniques, and with an atmosphere of management acceptance to understand and implement new capabilities, the defense acquisition community can evolve from its present state of reactive management to a more desirable climate of proactive cost and schedule control.

INTRODUCTION

The defense acquisition community has achieved conspicuously noteworthy successes over the past decade. These achievements are nowhere better substantiated than in the dramatic successes witnessed in Operation Desert Storm in the air, on land, and at sea. The precipitous defense build-up of the Reagan era proved its merit by facilitating awesome battlefield successes at unprecedentedly low levels of American losses. The advent of radar-evading stealth aircraft, pilotless cruise missiles with astonishing accuracy, smart munitions and high precision bombing, GPS satellite navigation, and debilitating electronic warfare capabilities, to cite just a few examples, are a result of numerous success stories written by the defense acquisition community. These accomplishments have facilitated the projection of massive U.S. combat power with minimum loss of life and equipment. Additionally, the new generation of American weaponry has enabled a level of precision in military actions that has minimized non-combatant casualties and collateral damage to a degree unparalleled in the history of warfare.

Despite its achievements over the past decade, the defense acquisition community now faces a much more austere and challenging environment for the nineties. The reasons behind this change in climate are many. Foremost among these prevailing stimuli is the federal budget deficit. While fiscal operating deficits are not new to the U.S. Government, the reality of their denigrating effects is now accepted by most and, indeed, Congressional legislation over the past few years has established dire consequences for failure to reach deficit reduction targets. The ramifications of the budget debacle have solidly impacted the defense community, as well as other elements of the Government. Critics of the defense establishment may expect disproportionately greater cuts in defense compared to other sectors, owing in part to the trillion dollar Reagan build-up period, as well as to the second major stimulus affecting defense dollars: the virtual loss of our major strategic adversary.

The amazing events which have taken place in the Soviet Union and in Eastern Europe over the past two years appear to some to have effectively eliminated our primary strategic enemy. Suddenly, the rationale and justifications for defense preparedness which have prevailed since World War II are no longer valid. The advent of "peace in Europe" and the end of the Cold War were heralded by many as signs of a new world order, and calls for a "peace dividend" arose in many camps. Prior to the Iraqi invasion of Kuwait, it appeared that the defense budget was in serious decline, despite the proffered arguments of potential Third World conflicts and other secondary defense missions which were promulgated in the name of preserving our military capabilities. In the past eight months, the Gulf War and the retrenchment of democratic progress in the Soviet Union, not to mention significant threats to Perestroika and Gorbachev himself, have vividly portrayed the dangerous and uncertain conditions that still persist in our world. Yet, despite these omens, it presently appears that declining defense budgets will prevail in the nineties, albeit perhaps at a slower rate than originally anticipated just a year ago.

Given that the defense acquisition community must continue to develop and field the most advanced and unsurpassed military systems in the world, it appears that the fundamental reality of the next decade will be characterized by "doing more with less." The growing military and technological capabilities of potential adversaries, particularly those of Third World nations, implies that a hiatus in our continued evolution will be inexcusable. Our warfighting forces will come with ever greater challenges and requirements to the acquisition community despite the diminution of available resources. The challenges of the next decade include the need to lighten combat forces and enhance mobility to facilitate rapid deployment for global crisis responsiveness. Reductions in overseas basing imply that tactical and strategic forces will increasingly be based in CONUS, yet must be able to deploy and fight in a myriad of environments ranging from the desert to the jungle. The nonlinear battlefield, increasingly automated warfare, and multi-hot spot scenarios portray the complexities of the new decade. Furthermore, the pace of technological advancements will require ever faster development and procurement cycles to streamline the acquisition process so that systems are not obsolete by the time they are fielded.

It is thus clear that the defense acquisition community faces a new decade in which it must continue to maintain American defense technological superiority in an environment of declining resources and increasingly demanding and diverse requirements. To meet the coming challenges, it is imperative that all phases of the acquisition cycle must be fine-tuned in efficiency and efficaciousness. "Doing more with less" requires that we, as a community, achieve unprecedented levels of managerial acumen in the leadership of defense acquisition efforts.

This paper examines one dimension of acquisition reform for the environment of the nineties -- programmatic control of cost and schedule. We will review current qualitative and quantitative cost and schedule control techniques, and elucidate potential areas for improvement.

The Imperatives for Reforming Cost and Schedule Control. Demanding ever greater acquisition successes from a leaner defense acquisition community will require nearly defect-free management. Decisions regarding the allocation of scarce resources (budget dollars!) ranging from R&D, through full scale development, to deployment and sustainment of fielded systems, must all be made in an accurate and timely fashion. Selected programs must offer the highest payoffs in the most cost-effective manner. Payoffs must be measured in terms of their fundamental contribution to defense capabilities, i.e., the projection of flexible, highly controlled and coordinated decisive combat power when and where it is required. Cost-effectiveness must be measured in terms of overall return on investment of taxpayer equity in defense systems and capabilities. Senior management faces the challenging task of selecting only the most promising programs for funding, and the penalties for selecting a "non-winner" will be exacerbated by the opportunity loss incurred in a time of austerity. These opportunity costs can be quite severe, since modern defense systems are generally expensive and require a lengthly development and testing period.

Reforming cost and schedule control for defense programs is also motivated by stereotypical problems which have plagued many, if not most, acquisition efforts. Perhaps the most dramatic recent example of deficiencies in the current system was the cancellation of the Navy's A-12 program by Secretary of Defense Cheney. The primary reason for this cancellation was the loss of control over cost and schedule. In addition, the inability to accurately predict the overall cost and completion date was a major factor in management's loss of confidence which precipitated the termination decision.

Unfortunately, the A-12 program is not an isolated case. It appears that "on time and within budget" is generally the exception, not the rule, in defense acquisition. In a recent issue of Program Manager magazine, John L. Clay noted that, "The time to develop and acquire a major weapon system in the acquisition environment today is averaging more than a decade. Hundreds of discrete, interdependent tasks are involved. Estimating the length and logical sequence of each one is not easy. The fact that schedule variances occur should not be surprising. However, these variances are almost always unfavorable -- the actual schedule turns out to be longer than the prediction. Indeed, schedule optimism has become part of the defense acquisition culture." Similar remarks apply to control of cost in defense acquisition.

Philosophical Perspectives. How did we, the defense acquisition community, come to our present *modus operandi* for managing cost and schedule in our programs? Time and space limitations prevent a thorough review of our legacy, but a few remarks are appropriate here.

The extensive applications of scientific methods to management problems is a relatively young discipline. The discipline of Operations Research (OR) grew out of the need to solve complex management problems encountered during wartime operations in England and the United States during World War II. Following the war, OR techniques diffused into industrial management, and the theory and practice of management science became extensive. In the past decade, the widespread availability of prodigious computational power has engendered a proliferation of user-friendly management science tools. Today, sophisticated techniques, to include artificial intelligence (AI) and expert systems, are being introduced into computer-based decision support systems. (5)

In the late 1950s, significant advancements in management science were realized with the advent of the PERT and CPM techniques. PERT, or Program Evaluation and Review Technique, is an event-oriented network analysis tool which focuses attention on schedule control, whereas the Critical Path Method (CPM) is an activity-oriented tool which emphasizes the relationship between project cost and duration. PERT and CPM are conceptually quite similar to one another. In early applications, these network analysis tools were applied primarily to only the largest and most complex problems in program management due to the paucity of adequate computational power during that era. For example, the first application of PERT occurred in 1957 and involved the management of hundreds of thousands of tasks on the Navy's Polaris Missile Program, which involved 250 primes and over 9000 subcontractors. (3)

Today, PC-based versions of PERT and CPM are readily available, and most program mangers have access to these tools regardless of the size or complexity of their program. These assets are probably the most widespread theoretical techniques used today for cost and schedule planning in defense acquisition. Several philosophical points should be noted with regard to these analytical tools.

The first point concerns the fact that cost and schedule planning is inherently a stochastic estimation process. PERT appropriately recognizes this fact, and relies on three estimates of activity duration (most optimistic, most likely, and most pessimistic) to compute a weighted mean activity duration, assuming an appropriate underlying probability distribution such as the Beta distribution. The asymmetrical Beta distribution accounts for psychological biases in subjective estimates of optimistic and pessimistic durations. The temptation which undermines PERT implementation is to bypass a best-effort assessment of the three activity duration estimates, and simply "guesstimate" the mean activity duration. CPM focuses on the trade-off between cost and schedule, but *it is more properly* classified as a deterministic management tool as opposed to a stochastic technique. Thus, improperly implemented PERT (which does not treat cost at all) and CPM (even when properly implemented) fail to adequately address the fundamental probabilistic nature of cost-schedule estimation. Although other, more refined techniques do exist (for example, PERT/cost (5), an adaptive stochastic tool presently does not exist to facilitate proactive programmatic control of cost and schedule.

PERT/cost techniques in the early 1960s led to the Cost Schedule Planning and Control Specifications (C/SPEC) in the mid-'60s and ultimately to the Cost/Schedule Control System (C/SCS) in the late '60s. Current cost and schedule techniques are largely based on C/SCS, which was formally introduced by DODI 7000.2 in 1967[1]. Clearly, today's defense acquisition environment and our present computational and management capabilities are radically different than conditions of the late sixties. Although the criteria established in C/SCS are fundamentally sound and applicable today, they can certainly be augmented and tailored to best meet the acquisition environment of the 1990s.

The second philosophical perspective on cost and schedule control addresses the issue that a prerequisitic for successful program control is sound program planning. A program that is not well-planned and realistically baselined will never be successfully executed. This statement appears to be so plainly obvious as to be almost a tautology, yet many a program manager has stepped in to execute an inherited program that was never properly planned. Control of cost and schedule really begins in the program definition phase. Although this precept is addressed in C/SCS, it perhaps receives less emphasis in actual practice than it rightfully deserves.

A third area of general philosophical concern is the disparity in management perspectives regarding establishment of a programmatic cost and schedule baseline. One viewpoint maintains that an efficient Government Program Manager should tenaciously negotiate a virtually unattainable cost-schedule baseline. The rationale here is that such a baseline will best induce the contractor to complete the effort in the shortest possible time and for the least cost. Since the baseline is unrealistic, re-baselining the program is virtually inevitable at one or more points but, again, tenacity in negotiation will "keep the contractor's feet to the fire." One must also consider the negative side of this approach, which is that any such managed program is *ab initio* doomed to be over-cost and late. Furthermore, how do senior managers plan and control an amalgamation of fictitiously baselined programs? Although the hardcore proponents of this approach claim that it can execute a program in the best interests of the Government, the result of widespread adoption of this philosophy would lead to abject chaos in defense acquisition management.

Another managerial perspective that appears to exist in some industry as well as government program offices is that initial cost and schedule estimates must be artificially optimistic in order to "sell" the program. The view here is that it is relatively more difficult for senior defense management to terminate a program than it is for management to reject a proposed new-start. Thus, some zealots believe that an "end justifies the means" approach is necessary to establish programs that they believe in, and downstream re-baselining and/or cost-schedule overruns are acceptable evils. Despite the improprieties of such "buy-ins", they are not uncommon in defense acquisition. Again, the overall repercussions of "buy-ins" are non-optimal investment decisions for defense acquisition, and budgetary chaos due to inevitable re-baselining and overruns.

A fourth philosophical point concerns a broader perspective on defense acquisition, which views each system as an element within the integrated "system of systems" that comprise the infrastructure of our national defense. Ideally, one would want to make acquisition decisions based on a system's contribution to the cost-effective optimization of overall defense capability. Such an analysis would consider the four basic elements of procurement management -- life-cycle costs, schedule, performance, and supportability -- as well as the interplay and synergies between a particular weapon or support system, and other elements of the ensemble of defense systems with which it must be integrated. This is no small task! Indeed, our present level of analytical capabilities fall far short of this lofty goal of quantitative reasoning. Nevertheless, continual improvements in our managerial decision-making capabilities are being made, as in the application of AI techniques to decision support systems. Our present analytical capabilities are useful for "local optimization" problems in which various alternatives for a particular defense system requirement are intercompared, and the best solution to the particular problem is identified. However, our goal should be the development of techniques which can deal with problems of "global optimization" in which we attack the general problem of tailoring a mix of diverse systems into an optimized integrated framework of defense capabilities to meet generic mission requirements and threat environments.

The important point here is that cost and schedule control within a program will only be truly meaningful if the program itself makes an optimal contribution to the grand defense "system of systems". It is counterproductive to worry about controlling cost and schedule at the "microprogram" level when the defense "macroprogram" is not optimally tailored. The stringent constraints on the acquisition community in the next decade necessitate meticulous cost and schedule control within programs that have been selected from among competing projects based on their overall contribution to optimizing the defense macroprogram. Of course, we do not yet have the quantitative analytical tools to achieve this level of decision-making today, so we must strive to make the best possible acquisition investment decisions from our present more subjective foundation, and we must, nonetheless, continue to emphasize cost and schedule control at the "microprogram" level. But high priority should be given to the development of analytical tools that can optimally invest taxpayer equity in defense system, so that rigorous cost and schedule control at the program level truly makes sense.

Our fifth and final philosophical perspective is actually the central thesis of this paper: The new age of defense acquisition must incorporate powerful <u>proactive</u> cost and schedule control techniques. Although our present techniques do have an element of predictive and proactive control, they are largely reactive management tools and will become increasingly anachronistic in the new environment. We will discuss the reactive nature of the current Cost/Schedule Control System, and make observations on improvements to make it more proactively oriented, in our discussion of quantitative control measures later in this paper.

Tenets for a Proactive Control Framework. Proactive control of cost and schedule requires both qualitative and quantitative techniques. Underlying these techniques are several fundamental tenets for a proactive control framework. These principles are summarized in Table 1.

TABLE 1
PROACTIVE CONTROL PRINCIPLES

- SELECT ONLY OPTIMAL PROGRAMS.
- ESTABLISH AN ACHIEVABLE, REALISTIC PROGRAM BASELINE. EXPLICITLY ACCOUNT FOR RISKS USING STOCHASTIC METHODOLOGY.
- AWARD CONTRACTS ONLY TO COMPANIES THAT HAVE ACCEPTABLE COST/SCHEDULE PERFORMANCE HISTORIES.
- MOTIVATE COST/SCHEDULE PERFORMANCE IN THE CONTRACT.
- IMPLEMENT AN OPTIMALLY STREAMLINED COST/SCHEDULE CONTROL SYSTEM TAILORED TO THE PARTICULAR PROGRAM.
- PERIODICALLY REVIEW COST/SCHEDULE PERFORMANCE
  - ANALYZE VARIANCES AND IMPLEMENT CORRECTIVE STRATEGY (REACTIVE COMPONENT).
  - REVISE PROBABILITIES FOR FUTURE COST/SCHEDULE PERFORMANCE BASED ON PERFORMANCE TO - DATE (PROACTIVE COMPONENT).
- FORECAST FUTURE COST/SCHEDULE PERFORMANCE USING REVISED PROBABILITIES.
- KEEP SENIOR MANAGEMENT ACCURATELY INFORMED.
- ASSESS OVERALL SCHEDULE AND COST-TO-COMPLETE VS. PROGRAM RESOURCES AND REQUIREMENT.
  MANAGEMENT OPTIONS:
  - "STAY THE COURSE"
  - REPROGRAM
  - TERMINATE EFFORT

These basic tenets incorporate both qualitative and quantitative means of managing cost andschedule in defense programs. The implementation of these general principles will be discussed in the following sections on qualitative and quantitative control measures.

Qualitative Control Measures. The first qualitative control measure involves steadfast integrity in the establishment of a realistic program baseline. Over-optimistic cost and schedule estimates may result from "buy-in's" or overzealous government negotiations but, whatever the cause, such fictitious baselining has no place in defense acquisition. Indeed, we have noted that such practices will wreak havoc in the coming environment of the nineties. The uncertainties inherent in estimating cost and schedule should not manifest themselves as overly optimistic or overly pessimistic baselines, but rather as properly constructed stochastic baselines in which subjective probabilities are assigned to optimistic, pessimistic, and most likely cost and schedule estimates. We will discuss the quantitative aspects of this point in the following section.

An objective assessment of a contractor's past cost/schedule performance should be a factor in the source selection process. If a home improvement contractor refinished your kitchen for double his estimates of cost and schedule, you would certainly think twice about giving him your next home improvement project. Yet, in general, defense acquisition does not systematically and objectively monitor contractor cost/schedule performance with an eye towards acceptability for future projects. A fair, objective set of evaluation criteria for defense contractor performance can, and should, be established. Quantitative measures of performance can be applied in an unbiased manner, and past cost/schedule performance can be qualitatively factored into the source selection process. This type of practice is a significant proactive control technique which should motivate defense contractors in the pursuit of continual high quality cost/schedule performance.

The contract vehicle itself is also an important tool for proactive cost/schedule control. A reasonably diverse set of contract types is available for defense programs. Tying cost/schedule performance to financial rewards via instruments such as Firm Fixed Price, and Cost Plus Incentive Fee (CPIF) or Fixed Price Incentive contracts, can help to motivate contractor "ownership" of the effort. Of course, in research and development programs where risks are high, the Government usually shoulders all, or a substantial fraction, of the development risk. But most, if not all, R&D efforts can be appropriately structured such that a CPIF framework can be utilized. Alternatively, if a Cost Plus Fixed Fee contract is employed, well-defined milestones should be established during the course of the R&D effort to clearly assess technical as well as cost and schedule performance. The risks to the Government of serial re-baselining clearly warrant a set of management decision-points to be built into the contract structure, perhaps in the form of multi-phased project options. Contractual "teeth" can help ensure that a contractor's "best efforts" really are the best possible.

The Cost/Schedule Control System criteria emphasizes the use of a tailored program C/SCS built around the contractor's internal corporate system for management control. Recent emphasis on streamlining the acquisition process to reduce costs and speed products to the field imply that C/SCSs should likewise be streamlined. Indeed, excessive documentation is often cited as a prime candidate to be streamlined in defense programs. This is actually an extremely difficult goal to properly accomplish, requiring experienced managerial insights. Too little documentation results in a program that is difficult or impossible to control, whereas too much is wasteful and burdensome, not to mention costly. Reliance on expertise within DoD, such as the resources of the Defense Systems Management College, can perhaps assist Program Managers to optimally tailor their C/SCSs in a streamlined fashion.

Keeping senior management informed in an accurate and timely manner is a well recognized responsibility of Program Managers. Fulfilling this responsibility requires the managerial and organizational skills to accurately capture the technical, cost, and schedule status of the program, and the integrity and courage to faithfully report that assessment to senior management. In the next decade, the austere defense acquisition environment makes this basic program management responsibility all the more important, since senior management's responsibility to optimally allocate resources hinges on accurate knowledge of performance in the programs they oversee.

Periodic reviews of overall schedule and cost-to-complete should be undertaken by the program office and reviewed by senior management. Again, this basic facet of cost and schedule control becomes increasingly important in the new acquisition climate. The goal of a proactive review cycle should be to keep the effort on target and to limit divergences from the baseline that necessitate formal reprogramming. The proactive philosophy requires that trends be diagnosed early and resources marshalled to counteract divergences from the baseline.

Perhaps the toughest decision that defense acquisition managers face is program termination. An effort which is judged off-track and continuously eroding may not be "fixable" by reprogramming due to latent defects in the program structure (unreliable contractor, drastically unrealistic initial baseline, unachievable technical goals, etc.). In such cases, government managers must make the tough, but necessary, decision to kill a program. Developing proactive quantitative control techniques will be essential to limit the losses suffered on a failed program by identifying a terminal case as early as possible. The next section addresses potential refinements to quantitative control measures in C/SCS.

Quantitative Control Measures. The C/SCS framework which has worked well for the past several decades is solidly based on good management practices. However, the cost/schedule control system should be a "living framework" that evolves as our theoretical foundations and implementation capabilities expand. As discussed earlier, more powerful and proactive control techniques can be implemented in the current age of proliferated computational and information systems which can be highly networked over our modern telecommunications infrastructure. For example, there is no major impediment to highly detailed and timely program control information being provided to the Government program office. Indeed, simply linking PCs over commercial networks can place a wealth of data in the PM's office, and this data can be analyzed with sophisticated tools using appropriate software resources.

In order to elucidate potential improvements to the current form of C/SCS, a review of key features of this system is in order. Figure 1 illustrates the fundamental time-phased program budget and the basic terminology (acronyms) of C/SCS. Table 2 provides definitions of key terms, and Table 3 summarizes the performance measures used to assess a contractor's progress.

Central to C/SCS is the concept of earned value, which is used to quantitatively measure planned and completed work. Earned valve is expressed in dollars. BCWS is the value of planned work, BCWP is the value of work which has been performed, and ACWP is the actual cost of the performed work. The fundamental indicators of cost and schedule performance in C/SCS are the cost variance and the schedule variance, respectively. As indicated in Table 3, these variances, as well as the major performance indices of C/SCS, are all based directly on the values of BCWS, BCWP, and ACWP. A program manager periodically receives progress data from the contractor, from which current values of the variances and performance indices can be calculated.

FIGURE 1
TIME-PHASED PROGRAM BUDGET
AND PERFORMANCE MEASUREMENT BASELINE
(Extracted from Reference 1)

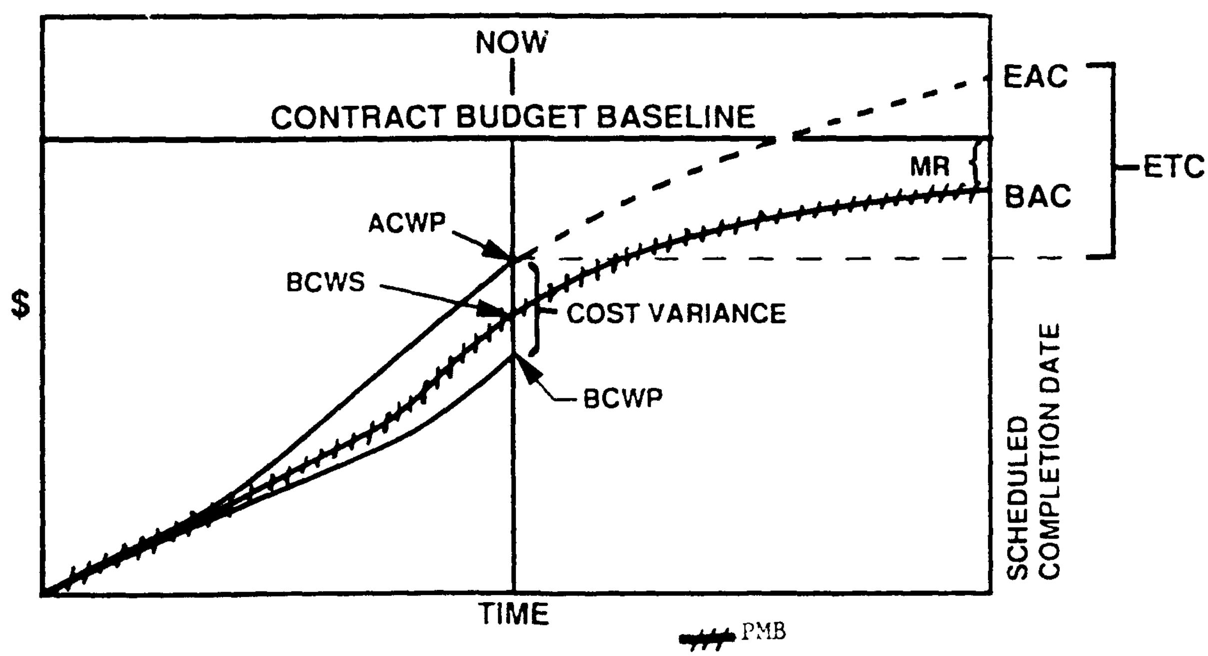


TABLE 2

KEY C/SCS TERMINOLOGY (EXTRACTED FROM AMC - P 715-5)

Budgeted Cost for Work Scheduled (BCWS). The sum of the budgets for all work packages, planning packages, etc., scheduled to be accomplished (including in-process work packages), plus the amount of level of effort and apportioned effort scheduled to be accomplished within a given time period.

Budgeted Cost for Work Performed (BCWP). The sum of the budgets for completed work packages and completed portions of open work packages, plus the applicable portion of the budgets for level of effort and apportioned effort.

Actual Cost of Work Performed (ACWP). The costs actually incurred and recorded in accomplishing the work performed within a given time period.

Contract Budget Base. The negotiated contract cost plus the estimated cost of authorized unpriced work.

Total Allocated Budget. The sum of all budgets allocated to the contract. Total allocated budget consists of the performance measurement baseline and all management reserve. The total allocated budget will reconcile directly to the contract budget base. Any differences will be documented as to quantity and cause.

Undistributed Budget. Budget applicable to contract effort which has not yet been identified to CWBS elements at or below the lowest level of reporting to the Government.

Significant Variances. Those differences between planned and actual performance which require further review, analysis, or action. Appropriate thresholds should be established as to the magnitude of variances which will require variance analysis.

Estimate a Completion (EAC). Actual direct costs, plus indirect costs allocable to the contract, plus the estimate of costs (direct and indirect) for authorized work remaining.

Reprogramming. Replanning of the effort remaining in the contract, resulting in a new budget allocation which exceeds the contract budget base.

Internal Replanning. Replanning actions performed by the contractor for remaining effort within the recognized total allocated budget.

Authorized Work. That effort which has been definitized and is on contract plus that effort for which definitized contract costs have not been agreed to but for which written authorization has been received.

Performance Measurement Baseline (PMB). The time-phased budget plan against which contract performance is measured. It is formed by the budgets assigned to scheduled cost accounts and the applicable indirect budgets. For future effort, not planned to the cost account level, the performance measurement baseline also includes budgets assigned to higher level CWBS elements, and undistributed budgets. It equals the total allocated budget less management reserve.

Planning Package. A logical aggregation of work within a cost account, normally the far-term effort, that can be identified and budgeted in early baseline planning, but is not yet defined into work packages.

Cost Account. A management control point at which actual costs can be accumulated and compared to budgeted cost of work performed. A cost account is a natural control point for cost/schedule planning and control since it represents the work assigned to one responsible organizational element on one contract work breakdown structure (CWBS) element.

Work Breakdown Structure (WBS). A product-oriented family tree division of hardware, software, services, and other work tasks which organizes, defines, and graphically displays the product to be produced as well as the work to be accomplished to achieve the specified product.

Work Package Budgets. Resources which are formally assigned by the contractor to accomplish a work package, expressed in dollars, hours standards or other definitive units.

Work Packages. Detailed short-span jobs, or material items, identified by the contractor for accomplishing work required to complete the contract. A work package has the following characteristics: (1) it represents units of work at levels where work is performed; (2) it is clearly distinguished from all other work packages; (3) it is assignable to a single organizational element; (4) it has scheduled start and completion dates and, as applicable, interim milestones, all of which are representative of physical accomplishment; (5) it has a budget or assigned value expressed in terms of dollars, man-hours, or other measurable units; (6) its duration is limited to a relatively short span of time or it is subdivided by discrete value milestones to facilitate the objective measurement of work performed; and (7) it is integrated with detailed engineering, manufacturing, or other schedules.

Management Reserve. (Synonymous with Management Reserve Budget.) An amount of the total allocated budget withheld for management control purposes rather than designated for the accomplishment of a specific task or set of tasks. It is not a part of the Performance Measurement Baseline.

Negotiated Contract Cost. The estimated cost negotiated in a cost-plus-fixed-fee contract or the negotiated contract target cost in either fixed-price-incentive contract or a cost-plus-incentive-fee contract.

Original Budget. The budget established at, or near, the time the contract was signed, based on the negotiated contract cost.

TABLE 3
PERFORMANCE MEASURES
(extracted from Reference 1)

SCHEDULE VARIANCE

- **Schedule Variance (SV)**

SV = (work accomplished) - (work scheduled)

SV = BCWP - BCWS

NOTE: Negative variance means less work was accomplished than planned but <u>not necessarily</u> behind schedule

- **Schedule Variance Percentage (SV%)**

$$SV\% = \frac{SV}{BCWS}$$

COST VARIANCE

- **Cost Variance (CV)**

CV = (work accomplished) - (actual cost of work accomplished)

CV = BCWP - ACWP

(A negative variance means more money was spent for the work accomplished than was planned)

- **Cost Variance Percentage (CV%)**

$$CV\% = \frac{CV}{BCWP}$$

SCHEDULE PERFORMANCE INDICES

- **Schedule Performance Index (Efficiency)**

$$SPI\ (E) = \frac{\text{Work accomplished}}{\text{Work scheduled}}$$

$$SPI\ (E) = \frac{BCWP}{BCWS}$$

- **Schedule Performance Index (Performance)**

$$SPI\ (P) = \frac{BCWS}{BCWP}$$

COST PERFORMANCE INDICES

- **Cost Performance Index (Efficiency)**

$$CPI\ (E) = \frac{\text{Planned cost of work accomplished}}{\text{Actual cost of work accomplished}}$$

$$CPI\ (E) = \frac{BCWP}{ACWP} \qquad \text{(e.g., CPI (E) = .90)}$$

- **Cost Performance Index (Performance)**

$$CPI\ (P) = \frac{ACWP}{BCWP} \qquad \text{(e.g., CPI (P) = 1.10)}$$

PERCENT COMPLETE

- Percent Complete - Relationship of the amount of budget (work) accomplished to date (BCWP) to the amount of budget (work) planned for the total contract (BAC)

$$\%\ \text{Complete} = \frac{BCWP}{BAC}$$

PERCENT SPENT

- Percent Spent - Relationship of the amount spent-to-date (ACWP) to the amount specified on the contract (BAC)

$$\%\ \text{Spent} = \frac{ACWP}{BAC}$$

$$EAC = ACWP + ETC$$

$$\begin{pmatrix}\text{ESTIMATED COST}\\ \text{AT COMPLETION}\end{pmatrix} = \begin{pmatrix}\text{ACTUAL COST OF}\\ \text{WORK PERFORMED}\end{pmatrix} + \begin{pmatrix}\text{ESTIMATED COST}\\ \text{TO COMPLETE}\end{pmatrix}$$

The reactive nature of this control system is quite obvious. Data is acquired on past performance, and variances and performance indices are calculated based on the past period. Management then reviews these indicators and subjectively assesses the health of the contracted effort.

It is unfair to say that the C/SCS philosophy and methodology is purely reactive. In practice, the period between successive contractor reports is fairly short (typically monthly or quarterly), so that "stale data" should not hinder the cost and schedule control effort. Furthermore, trends in the sequence of variances and performance indices can be studied, and subjective estimates of future performance can be made. Use of PCs to perform this tracking function could certainly be implemented, and indeed the Defense Systems Management College has developed software capabilities which nicely perform this function, to include graphical representations of the data.

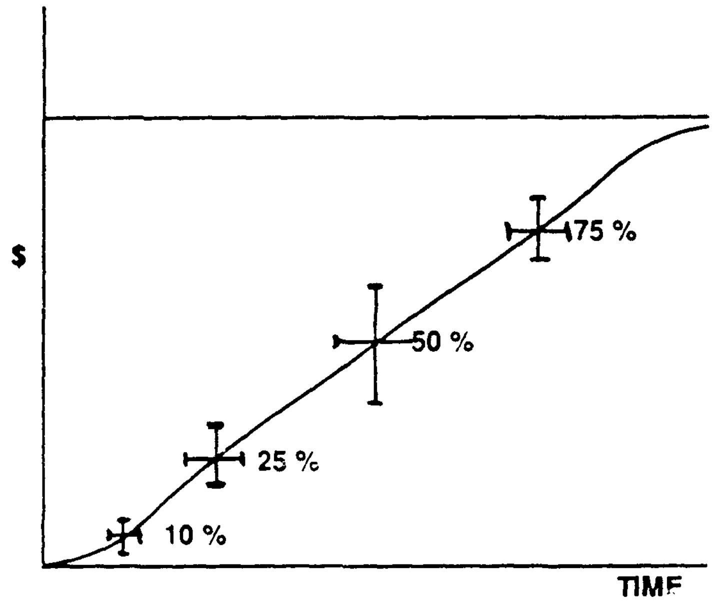
Nevertheless, it is fair to say that present C/SCS methodology does not incorporate well-developed forecasting tools. This is our first identified quantitative refinement to C/SCS. Given that trend data are available, it would be fairly straightforward to utilize forecasting aids such as linear (or higher order) regression analyses, moving averages, or weighted exponential forecasting techniques. Given that most program offices today have PCs available, regardless of the size of their program, these techniques can make a significant contribution to the quantitative assessment of contractor performance in the coming work periods. Of course, subjective review and assessment by the program manager will always be essential in gauging future trends and expectations of performance, especially where intangible and non-quantitatively measurable factors must be considered (morale, key personnel changes, etc.). But available forecasting tools can, and should, be integrated into the C/SCS framework as an aid for management. The goal, of course should be a fine-tuned diagnosis of significant adverse trends that warrant managerial attention to rectify without overly reacting to every fluctuation in the stream of performance data. Statistical techniques can greatly assist the program manger to "separate the wheat from the chaff."

Another improvement which can be made in current C/SCS methodology is an explicit accounting for risk in the program baseline. The program master schedule may be developed with the aid of a stochastic planning tool such as PERT, which can treat optimistic, most likely, and pessimistic estimates of task durations. However, these estimates are usually used to develop a mean activity duration, which is then incorporated into the master schedule. The probabilistic nature of the task durations is subsequently "lost" in what becomes a pseudo-determinisitic schedule against which performance is measured. Similar remarks apply to the treatment of cost data. A possible improvement to this current methodology would be to establish a well-defined program baseline, but to track uncertainties explicitly in the cost/schedule analytical procedures. Although a more thorough, detailed study is warranted in this area, a few preliminary observations will be made.

The performance measurement baseline is actually the aggregation of time-phased <u>mean</u> activity durations, but the probability distributions along the cost and schedule dimensions should be preserved as useful tools for analysis. If a well-planned, high fidelity baseline is <u>properly</u> established, then one expects to see fluctuations, both favorable and unfavorable, as the program progresses. The definition of <u>significant variance</u> is today a subjective derivation in C/SCS, whereas this definition can be rigorously made based on the uncertainties expressed by the respective probability distributions. Figure 2 illustrates error bars along the performance measurement baseline (PMB); these error bars graphically indicate the uncertainties inherent in the estimated mean cost of the program at the respective times. Figure 2 represents a variation on the traditional C/SCS PMB. This plot uses the same axial labels as the traditional plot, but now time, as well as cost, is treated as a dependent variable. The independent variable is now taken as the percent completion factor

FIGURE 2

MODIFIED PERFORMANCE MEASUREMENT BASELINE



for the entire project, and is calculated based on the ratio of BCWS (dollars) to the Budget at Completion (BAC). As an example, consider the set of completed work packages (to include partially complete packages measured on a percentage basis) which has a total aggregate of budget dollars equal to 5% of BAC. We define this point along the PMB as "the 5% completion point." To plot this point on the Cost-Time graph, we use the respective BCWS dollars and the sum of the mean task durations that take us to the 5% completion point. The PMB itself is then simply the locus of cost-time points as we go from 0% to 100% of project completion.

At this point, it may appear that we have done nothing more than semantically redefine the PMB plot. However, the true conceptual advantage of this construction is the direct incorporation of uncertainties in both cost and time along the PMB. The program manager now has a powerful tool to quantitatively assess the significance of variances. For simplicity in illustration, let us assume that the probability distributions on both the cost and time dimensions are Gaussian, and let us define variances greater than one standard deviation (one sigma) as "significant variances." The program manager is analyzing performance at a particular point in time, and calculates the cost and schedule variances from BCWS, BCWP, and ACWP in the usual manner. If the magnitude of these variances exceeds the one sigma level, they are considered to be significant. This is not to say that the PM should ignore unfavorable variances less than one sigma, but rather this criterion serves as a yardstick against which the PM can gauge the appropriate level for his concern and concomitant corrective actions.

Graphically displaying uncertainties in an explicit fashion can help the Program Manager see the potential "bottlenecks" in his or her program. This technique could also be incorporated into PERT/CPM type analyses by tracking and displaying the set of cost and schedule estimates instead of forming mean values from them. (Although the following discussion could be adapted to PERT/CPM techniques, we will continue to use C/SCS as our model for illustration.) In addition to identifying possible "bottlenecks", tracking the inherent uncertainties in cost and schedule estimates will prevent the PM from suffering "delusions of successful performance." For example, a contractor may be right on target, or even experiencing favorable variances, during the first three years of a four-year effort. But if 95% of the technical risk is located in the last few months of the program, then the successful performance to-date is not a valid indicator, or trend description, to assess the prospects for overall successful completion of the project. But a graphical display of uncertainties would make this quite obvious by the large error bars at the tail-end of the program.

If the total utility of this approach was simply to aid as a "yardstick" for the PM, it might be a questionable augmentation to C/SCS. But there are two other aspects to using this technique. First, the PM can now assess the contractor's performance in units of time directly. For example, suppose that BCWS at the time in question was 50% of the BAC dollar value. Since the PMB has been labelled with "percent complete" benchmarks calculated as the ratio BCWS/BAC, we can look at the percent completion point along the PMB which corresponds to the ratio BCWP/BAC. This is a simplistic way to portray the point along the PMB that corresponds to the actual percent complete, and the time when we should have reached this point is then read directly off the time axis. We now have a schedule variance in days (or months, as appropriate) and the significance of this temporal variance can be assessed by comparison to the error bar along the time dimension at the current epoch, analogous to our above discussion for the significance of a cost variance.

It was noted that his technique is actually over-simplified. The subtlety here has to do with the fact that the PMB construction assumes a certain flow of completed work packages, whereas at a given instant in time, the mix of actually completed (or partially completed) packages may differ from the baseline project network. By dealing with progress in each separate work package directly, and maintaining a comprehensive data base of the time history of work package progress, this subtle over-simplifying defect in the above argument can be obviated. Even relatively large projects could be monitored this way using available computers, but it doesn't appear possible to convey this information on a 2-D graph that combines simplicity and ease of visualization across the time-phased history of the program.

The second aspect of the utility of this method lies in its ability to facilitate continuously revised risk assessments <u>without re-baselining</u> the program. To see this, we must first recognize that the risk or uncertainty at any stage of the program is conveyed by the width of the probability distributions associated with a given point along the PMB. The wider the distribution (i.e., larger standard deviation), the greater the uncertainty in the respective point on the PMB and, hence, the greater the risk to cost and/or schedule. One can imagine varying the uncertainties along the PMB without altering the mean value of the sequence of probability distributions, i..e, without changing the PMB itself. Modifying the PMB corresponds to a re-baselining or reprogramming action; hence, if we can track the changes in the probability distributions as the project progresses, we can revise the risk assessment for the program without re-baselining it. This technique might actually help to thrwart tendencies toward "rubber baselining," since reprogramming need occur only after the uncertainties along the PMB become excessively large.

How then, do we revise the probabilities as we progress through a program? This question warrants further detailed analysis, but some initial considerations may be offered here. The simplest approach appears to be the use of Bayes' Theorem to revise *a priori* probabilities after new information is obtained. Initially, we have a set of subjective probabilities (corresponding to optimistic, pessimistic, and most likely cost estimates) that are assigned to each increment along the PMB (say every 5 or 10 percentage points in terms of project completion). Ideally, these subjective probabilities are established at the work package level and projected onto larger phases of the project; however, they may be estimated at a level much above the work package for simplicity. After progressing for some period through the project, we have gathered actual data on cost and schedule, and we might use this data in Bayes Theorem to revise the probabilities associated with future phases of the program.

Finally, one other point warrants brief discussion, namely, the incorporation of the "quality dimension" into the basic program management framework. Considerable attention has been focused recently within DoD on the principles of Total Quality Management (TQM), yet an wholistic structure for treating technical performance and quality control within an integrated Cost/Schedule/Quality framework has yet to be elucidated. Of course, Program Managers today spend considerable time and effort managing the technical side of their programs, but there appears to be a distinction between managing the technical side of the program compared to the cost/schedule side. Although trade-off decisions typically involve the triumvirate of cost, schedule, and performance, we generally do not see continual tracking of these three fundamental parameters in an integrated sense. Perhaps a future TQM-based version of C/SCS will make progress in this area.

SUMMARY AND CONCLUSIONS

This paper has reviewed the challenging environment which will confront the acquisition community in the nineties, and its concomitant requirements for rigorous cost and schedule control in defense programs. We have discussed qualitative and quantitative control measures as presently defined and implemented, and we have critiqued these practices and assessed several areas for improvements. The suggestions for timely augmentations and improvements to the present Cost/Schedule Control System should certainly be viewed as evolutionary embellishments to the fundamentally sound C/SCS principles. Our observations and analysis lead to the following conclusions:

(1) Cost and schedule control really begins in the pre-contract award phase. Realism and integrity must characterize cost and schedule proposals from industry, and the Government Program Manager must have the courage and tenacity to obtain a feasible baseline for his or her program. "Buy-ins" and over-optimistic program selling have no place in the acquisition environment.

(2) Rigorous implementation of available cost and schedule control tools should be adopted by <u>all</u> program offices, regardless of the size of their program. In the current age of proliferated microcomputers and sophisticated software packages, there is little reason why accurate, proactive control of cost and schedule cannot be universally implemented in the defense acquisition arena.

(3) The current "tool kit" of cost and schedule control measures warrants some updating and revision. A proactive form of C/SCS requires implementation of appropriate forecasting techniques. Present techniques have evolved from a past climate in which adequate computational power to perform sophisticated analyses did not exist. Today, virtually all program offices have *high-powered hardware and* software assets, and more rigorous analytical tools should be established. As an illustration of an extrapolation to C/SCS and PERT/CPM techniques, a framework for continual re-assessment of uncertainties and risks was presented. This technique can serve the dual purposes of refining management's perception of cost and schedule risk estimates for downstream phases of the program (i.e., phases occurring after the nominal assessment date), and serving as an ongoing evaluation of the contractor's ability to estimate cost and schedule and perform to those estimates. Additional research and analysis is warranted to

refine theoretical foundations for proactive cost and schedule control techniques. The availability of computational resources implies that management need not bog down in the theory or detailed calculations of sophisticated analytical tools, but rather a good understanding of the analytical product and its implications for management control of a program are the key elements for operational utility. Of course, overcoming psychological inertia and "fears" of powerful new tools will be essential if such capabilities are to be successfully implemented by Program Managers.

(4) Proactive control can be greatly facilitated by adding contractor cost and schedule performance history to the contract award criteria. Maintaining a centralized DoD database of performance history, and tying a bidder's track-record to consideration for a new award, will accomplish several objectives. These goals include motivating high fidelity cost and schedule estimation in the proposal process, and dogmatic adherence to cost and schedule baselines lest poor performance jeopardize a contractor's chances for future contract awards.

(5) The prospect of high fidelity combat simulation tools in the coming decade portend a new dimension in acquisition decision making. For the first time in history, we have the prospect of quantitative comparisons of the potential military utility and cost-effectiveness of the diverse components of the grand defense "system of systems." Adding this non-subjective assessment capability to the acquisition decision-making process will take us markedly closer to the idealistic goal of formulating the optimal mix of weapon systems and support infrastructure to accomplish defense missions within the limits of constrained resources. Much detailed analytical work remains to be done in this area if the acquisition community is to maximally leverage off the tremendous advances in simulation capabilities that are expected over the next decade.

With further study and elucidation of cost and schedule control techniques, and with an atmosphere of management acceptance to understand and implement new capabilities, the defense acquisition community can evolve from its present state of reactive management to a much more desirable climate of proactive cost and schedule control. The positive benefits of a proactive control philosophy will significantly contribute to acquisition successes during the challenging decade of the nineties.

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A DUAL-SOURCING AUTOPSY:AN EMPIRICAL INVESTIGATION INTO COMPETITION POLICY FOR THE 90'S

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ABSTRACT

From figuring prominently in the 1981 Carlucci Initiatives, to becoming a matter of law in the 1984 Competition in Contracting Act (CICA), competition became a defense procurement obsession during the last decade.

But is our 1980's procurement policy flexible enough to address the fast-changing acquisition environment of the 1990's? Today's dynamic environment has strengthened the need to examine defense procurement policy.

The purpose of this study is to suggest defense procurement policy changes for the 1990's by investigating dual-sourcing, one of the more controversial competition policies. Dual-sourcing has been the focus of considerable research and debate. However, most of this research has a "policy-maker" perspective and few are empirical investigations. This study, on the other hand, investigates the views of the "implementers" of procurement policy. The attitudes and opinions of these people are analyzed to answer questions about adapting defense procurement policy to the needs of the 1990's.

The research methodology for this study was to approach the same questions from two perspectives. First, a survey of the attitudes and opinions of competition policy implementers was accomplished using a research questionnaire. Next, an analysis of the effects of dual sourcing on the financial condition of selected firms and industry sectors was accomplished by using a financial data-base service.

Through our analysis, we can answer the three research questions of the study. First: do the attitudes and opinions of defense competition "policy implementers" differ from those of "policy makers" as concerns dual sourcing? The answer is yes. The policy makers and the implementers seem in agreement that dual sourcing makes sense only given the strict conditions of a long production run, low initial investment costs, and low technology transfer costs.

Second: Does dual sourcing enhance the quality of major weapon systems? There is no inherent incompatibility between dual sourcing and quality. However, it seems whenever the government uses any form of competition for production units, low cost seems to be stressed at the expense of everything else, including quality.

Third: Should current procurement policy be modified to meet the changes of the 1990's? The answer is clear: an emphatic YES! What is important here is that the policy changes reflect the changes in the environment. Policy makers should consult with policy implementers to ensure that in the 1990's, acquisition policy reflects the reality of our changing defense needs.

In short, dual sourcing probably still has a role to play in the defense acquisition process. But this role is clearly a cameo, limited to unique circumstances having particular characteristics. We hope for a policy which reflects the environment of the times and builds on the acquisition system's current strengths, which clearly outweigh the weaknesses.

A DUAL-SOURCING AUTOPSY: AN EMPIRICAL INVESTIGATION INTO COMPETITION POLICY FOR THE 90'S

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"Competition, whatever we label it, is an institutionalized fact of life for the Air Force and is embedded in our acquisition activities."(AFRP 190-1, Jan 88)
Gen Monroe W. Hatch Jr.
AF Vice Chief of Staff

INTRODUCTION

From figuring prominently in the 1981 Carlucci Initiatives, to becoming a matter of law in the 1984 Competition in Contracting Act (CICA), competition became a defense procurement obsession during the last decade.

This came as no surprise. Basic economic theory suggests competition will enhance performance and ultimately reduce the costs of products, hence increasing their value. Congress persistently expressed a conviction that competition had similar beneficial effects when procuring major weapon systems. The government defense establishment embraced competition not only as a means for improving weapon systems value, but also as a way of satisfying critics of acquisition policy. Consequently, during a decade of unparalleled peacetime defense expansion, competition played an important role in Department of Defense (DoD) acquisition policy. Competition techniques, including dual-sourcing, emerged as tools for achieving the age-old procurement quest of getting the most bang for the buck.

But is our 1980's procurement policy flexible enough to address the fast-changing acquisition environment of the 1990's? Some argue that the epochal changes in Europe, coupled with pressure to reduce the federal budget deficit, are enough to turn current defense acquisition policy upside-down. Intensifying these pressures are other changes in the acquisition environment, including an alarming reduction in the defense industrial base. This dynamic environment has strengthened the need to examine defense procurement policy.

PURPOSE

The purpose of this study is to suggest defense procurement policy changes for the 1990's by investigating dual-sourcing, one of the more controversial competition policies. Dual-sourcing has been the focus of considerable research and debate. However, most of this research has a "policy-maker" perspective and few are empirical investigations. This study, on the other hand, investigates the views of the "implementers" of procurement policy. The attitudes and opinions of these people will be analyzed to answer questions about adapting defense procurement policy to the needs of the 1990's. Specifically, this study will attempt to answer the following questions:

1. Do the attitudes and opinions of defense competition "policy implementers" differ from those of "policy makers"?

2. Does dual-sourcing enhance the quality of major weapon systems?

3. Should current procurement policy be modified to meet the changes of the 1990's?

After a background description of competition policy and dual-sourcing, the research approach for this study will be detailed. A summary of the empirical findings of a detailed survey will be presented along with an analysis of selected financial data. Finally, conclusions and recommendations will be derived and presented.

BACKGROUND

As Congressional and public interest about competition in weapon systems acquisition increased, so did the research. The result was many research papers, exposes, and committee hearings; and eventually the enactment of several laws which advocated commercial-style competition. Some see the DoD competition initiatives of the 1980's as one of this country's most significant modern regulatory reform efforts (Kovacic 89, p.253). But the idea that competition would substantially decrease weapon systems cost was put forth many times prior to the 1980's. Secretary of Defense Robert S. McNamara testified to Congress in 1965 of 25% savings resulting from competition (Sellers 83, p.12); as did J. Ronald Fox, a former Assistant Secretary of the Army and noted acquisition expert (Fox 74, p. 256). The exponential rise in the cost of new weapons, coupled with unfavorable press regarding the government's inefficiency in procuring weapon systems, made the potential benefits associated with competition too attractive to ignore.

Ultimately, Congressional pressures prevailed, and competition policy evolved to annual competitions among qualified bidders for a winner-take-all stake for certain acquisitions. If the low bidder, and hence the winner of the competition, was not the developer, a second source had been born. Competition had accomplished its goals of reducing cost and risk while increasing the defense industrial base.

But technically complex systems require significant start-up and qualification costs and viable competition was often not feasible. This was the genesis of dual sourcing. The government's answer to a lack of competition was to have a hand in developing an alternative source through methods such as teaming, direct licensing and leader-follower relationships. This last approach included the actual transfer of technical data packages, specifications and blueprints. This action, commonly referred to as technology transfer, involved communicating "know-how" and "show-how." Sometimes this technology transfer actually required the relocation of the developing contractor's personnel into the recipient contractor plant (Kovacic 89, p.286).

DoD competition policy has evolved to focusing on creating a limited number of rival contractors that compete at different stages of the procurement process. The government has treated dual-source procurements as though the introduction of a second source would automatically reduce costs. The existence of a rival, or even a perception of a rival, was seen to be the vehicle for eventually reducing costs. Some authors were quick to point out that there was no coherent theoretical reason to assume that a duopoly (dual-source contractors), dealing with a monopsony (DoD), would consistently result in lower prices than the bilateral monopoly which generally characterized weapon systems acquisitions (Beltramo 83, p.44).

Other arguments against the idea that competition was the best way to reduce costs and increase efficiency in weapons procurement were brought up when authors took exception to the underlying assumption that the defense marketplace was directly comparable to traditional competitive markets (Beltramo 86, p.1). Additional arguments attacked the premise that defense competition actually led to lower costs. Authors asserted that comparisons of hypothetical sole-source prices to actual competition prices were misleading and led to conclusions of lower costs (Pilling 89, p.2).

The advocates of dual-sourcing often relied on "numbers" to prove their point. In the Navy's case, it was stated that in the 1980's, dual-sourcing had reduced unit prices of weapon systems and yielded an average of 14% savings to the government compared to sole-source production (Flynn & Harrin 89, p.iii). Other studies concluded that competitive production programs have obtained prices lower than those estimated for the contemplated sole-source procurement. They even contended that economic analyses rejecting competitive production should be greeted with skepticism by the program manager (Hodulich & Drinnon 90, p.16). A landmark DoD Inspector General (IG) Report concluded that dual-sourcing provides increased competition and is a viable technique for moving away from sole-source procurements (IG 88, p.i.). However, it also described the Military Department's claims of dual sourcing's substantial savings to the government as lacking in credibility (IG 88, p.7). Deputy Inspector General Derek J. Vander Schaaf took a moderate position stating that for lower cost items that are produced in large quantities, over a long period of time, dual sourcing may make a lot of sense (Morrison 90, p 1344).

The advantages and disadvantages of dual-sourcing are also well-documented. The advantages are both short-term, in the form of reduced unit costs and contractor responsiveness; and long-term, in the form of an enhanced industrial base and increased contractor capital investment. Other advantages include reduced regulatory oversight requirements, broader Congressional support for programs, and reduced postcontractual opportunism (Kovacic 89 pp.282-283). Disadvantages include the costs associated with technology transfer, duplication of nonrecurring fixed costs at contractor facilities, loss of economies of scale, potential contractor "gaming" with respect to bidding strategies, and increased support costs if multiple configurations result (Tyson et. al. 89, P.VII-2-3).

Considering these pros and cons and the changing acquisition environment, dual sourcing was selected as the focus of this study. An operational definition for dual-sourcing was developed in the context of the preceding background: "Any acquisition strategy designed to foster actual or realistic potential competition of production units, subunits or components capable of performing the same mission with the same effectiveness." (Green and Rappaport 90, p.8).

Other operational definitions for this study included the description of the sample population and the standards of comparisons. The "policy-makers" were considered to be the standard. They represent conventional wisdom regarding dual sourcing and are best illustrated by current competition legislation involving dual sourcing and the writings of advocates of the approach. The "implementers" of dual sourcing are considered the people in the field who actually must implement dual-sourcing policy. These people need not be critics of dual sourcing, but are required to fit a specific criterion to ensure valid population representation.

RESEARCH METHODOLOGY

The research methodology for this study was to approach the same questions from two perspectives. First, a survey of the attitudes and opinions of competition policy implementers was accomplished using a research questionnaire. The responses were statistically analyzed to arrive at findings, conclusions, and recommendations. Next, an analysis of the effects of dual sourcing on the financial condition of selected firms and industry sectors was accomplished by using a financial data-base service. Since each approach was so fundamentally different in nature, each will be described and reported separately.

Dual-Sourcing in the 1990's Questionnaire

To suggest credible action for competition policy for the next decade, we selected generally accepted research methods using an attitudinal survey (Kerlinger 73). A questionnaire was developed around a research paradigm involving the three questions about competition policy in the 1990's presented earlier. It was constructed to facilitate statistical analyses of the collected responses. These statistical findings were the foundations for the conclusions and recommendations of this study.

Critical to valid findings is the selection of a credible population. For the purpose of this study, we determined that all of the individuals associated with defense competition policy could be categorized into two general populations: the policy makers and the implementers. Narrowing this large population was accomplished by first concentrating on the competition policy implementers and then further focusing in on one subgroup: those specifically involved with dual-sourcing. The population ultimately selected was required to meet the following three criteria: (1) currently involved with weapon system acquisition, (2) have used or have been exposed to the Defense System Management College (DSMC) Competition Evaluation Model (CEM), and (3) willing to participate in the study.

We identified an initial population of 1056 people as potential participants in the study. These names were obtained from DSMC (on a confidential basis) as individuals who were identified as possessing the DSMC CEM. Having a copy of the CEM insured that they were at least exposed to the concept of dual sourcing. However, it did not insure a well-defined population for this study. Individuals that fit all three population criteria were identified from this large group through the use of a post card pre-survey (see Appendix 1). The 362 respondents to this pre-survey were categorized into 5 sub-groups of which only 121 individuals fit the population criterion (see Appendix 3). Through our methodology we could insure that our population was representative of current acquisition officials who are working on programs that are dual-sourced, or have been exposed to dual sourcing, and were interested in further participation in the study. They became the target population for receiving the "Dual-Sourcing in the 1990's Questionnaire."

The foundation for the "Dual-Sourcing in the 1990's Questionnaire" was the research questions (see Appendix 2). Ideas and concepts for questions were derived from topics and issues identified in current literature specifically addressing dual sourcing, such as work by Dr. Michael Beltramo in 1983, 1989, and 1990 and other cited in this study (Burnett and Kovacic 89, and Tyson et. al. 89), or were original ideas of the authors. Comments and criticisms obtained from a "Pilot Test of the Dual-Sourcing in the 1990's Questionnaire" and a presentation at the 24th Annual DoD Cost Analysis Symposium, September 1990, were incorporated into the questionnaire before final publication and distribution. The individuals asked to complete the pilot test were all considered nationally renowned experts in the area of dual-source procurement based upon their publications.

For most questions, Likert type scales were used to facilitate statistical analyses (Alreck and Settle 85, pp 133-135). Part I, Background Questions, included typical demographic information. Included was one bimodal response involving a choice between "Government" and "Contractor." This was used to facilitate sub-group division of the respondents. Part II, Policies and Practices of Dual Sourcing, was developed to help identify specific characteristics or experiences associated with dual sourcing. The data collected from this section predominantly addressed the study's first research question, "Do the attitudes and opinions of defense competition "policy implementers" differ from "policy makers"? Part III, Dual-Sourcing and Quality, was developed and designed to address the study's second research question, "Does dual sourcing enhance the quality of major weapon systems?" Since quality is an acquisition initiative receiving unprecedented management attention, we thought that causal interactions between dual sourcing and quality, if identified, would result in significant findings. Part IV, Potential for Dual Sourcing in the 1990's, focused on the study's third research question, "Should current procurement policy be modified to meet the changes of the 1990's?" Given the unstable global political environment,and the potential for threat reassessments, the 1990's promise to be a period of uncertainty for defense procurement. This section was designed to analyze the effects of these phenomena on current defense procurement policy.

Statistical Analysis of Questionnaire Responses

Three analysis criteria were established: (1) a sufficient number of questionnaires were returned and were usable, (2) all findings and conclusions would require statistically significant data-analysis results (0.05 level), and (3) the manipulation of the data would be held to a minimum to maintain credibility.

We achieved a 34% return rate on the 1056 post-cards, a 100% return rate on the 5 Pilot Tests, and a 42% return rate on the final version of the "Dual-Sourcing in the 1990's Questionnaire" prior to the December 1, 1990 deadline (see Appendix 3). Considering the selection process of the population, we determined that the response rate and the number of respondents to the questionnaire was sufficient to represent the population of all individuals involved in dual-source defense procurement.

The questionnaire was determined to have 49 input variables each. A matrix of 50 questionnaires with 49 input variables was constructed on an MS-DOS Edlin file. This data was then analyzed using SPSS-X VAX/VMS Statistical Package for the Social Sciences Analysis Program. Only the 38 responses that involved Likert Scales were chosen and a quantitative summary for each was performed. From these findings, questions with apparently strong results, either agreement or disagreement, were identified. Simultaneously, a statistical cross-correlation of these same 38 input variables using the Pearson Correlation Coefficient was performed to demonstrate the correlation between the findings of selected inputs compared with other predetermined inputs. Finally, Chi-Squared tests using demographic sub-group data were performed on 10 selected input questions that were previously determined to be pivotal in addressing the research questions of this study.

SELECTED FINDINGS

The findings for this study were derived from two sources: the results of statistical analyses of data collected from the "Dual-Sourcing in the 1990's Questionnaire" and analysis of selected financial data retrieved from the Compustat PC Plus Database. Selected findings from each approach are presented separately. All statistical analyzes can be found in Appendix 4.

"Dual-Sourcing in the 1990's Questionnaire" Selected Findings:

Part I: Background Questions

Based on the descriptive statistics of Part I, Background Questions, this study defines a typical dual-sourcing implementer as: A DSMC graduate with a Master's degree and ten years experience in defense acquisition. This person has been involved with dual-sourcing on one program and has been involved in at least one other program that has considered, but not implemented, dual-sourcing. In either case the typical dual-source implementer did not use the DSMC Competition Evaluation Model (CEM) to aid in decision making. Division of the total population of implementers into the sub-groups, government and contractor, was performed to assist in statistical analysis. This action revealed that most of the respondents considered themselves government as defined by the questionnaire (active duty military, civil service, Federally Funded Research and Development Contractor or NASA)

Part II: Policies and Practices of Dual Sourcing

The questions included in this part of the survey were designed to address the first research question: Do the attitudes and opinions of defense competition "implementers" differ from those of "policy makers"? Descriptive statistics revealed strong tendencies for implementers to either demonstrate relatively strong agreement or strong disagreement on specific statements involving dual-sourcing policy. Four predetermined questions in this part were selected for further statistical analysis because they represented either current dual-sourcing policy or were statements reflecting the opposite of current dual-sourcing policy. This was done to minimize bias or "leading" questions.

For example, Question #14, "In general, dual sourcing is a cost-effective acquisition technique and should continue to receive strong government endorsement," showed a trend toward the agree end of the scale. 50% of the implementers either agreed or strongly agreed with this contention while 34% either disagreed or strongly disagreed. 16% registered no opinion. Further statistical analysis, using a Chi-Square test on the government and contractor population sub-groups revealed a very significant (.000) difference in the way these implementers answered the question.

Additional statistical analysis using the Pearson-Correlation was performed to investigate the manner in which the implementers answered selected questions. This statistical test was employed to detect the probability that the implementers answered the questionnaire randomly. There was strong positive correlation (questions were answered similarly) with three questions and strong negative correlation (questions answered differently) with four other questions. For example, Part IV, Question #2, "Defense contractors are so eager for business, and the number of new programs so few, there is no need for government induced competition." experienced a strong negative correlation (-.7). This indicated that if the implementers agreed that dual sourcing was cost effective and should be continued (Part II, Question #14), they would disagree with the contention that there should not be government-induced competition (Part IV, Question #2). Not only does this type of analysis allow for investigation of the interactions between key questions, it adds credibility to conclusions and recommendations by demonstrating consistency in the manner in which the respondents completed the questionnaire.

Part III: Dual-Sourcing and Quality

The questions included in this part of the survey were designed to address the second research question of the study: Does dual-sourcing enhance the quality of major weapon systems? Descriptive statistics for this part, as in the previous part, demonstrated many strong bi-modal tendencies: either considerable disagreement or agreement with the statements included in the questionnaire. Three questions from this part were pre-selected for further statistical analysis because they represented statements which made the "implementers" reveal their attitudes and opinions regarding "policy makers" positions on the effects of dual sourcing and quality.

For example, Question #1, "Dual-sourcing helps promote quality (performance, reliability, etc.) because of the existence of a rival producer." had a strong trend toward the agree end of the scale. 58% either agreed or strongly agreed with this statement while 26% either disagreed or strongly disagreed. 16% of the "implementers" recorded no opinion. Further analysis revealed a very significant (.000) difference in the way these "implementers" answered the question.

Additional analysis was performed to investigate the manner in which the implementers responded to other pre-selected questions. There was strong positive correlation with 3 other questions and strong negative correlation with 5 other questions. For example, Part IV, Question #8, "Dual-sourcing should continue to be strongly advocated in the 1990's in order to maintain the defense industrial base." demonstrated a very strong positive correlation (.600). This verified that "implementers" agreeing with Part III, Question #1, also agreed with Part IV, Question #8, and the agreement was not due to chance.

Part IV: Potential for Dual Sourcing in the 1990's

The questions in this part of the survey were designed to address the study's third research question: Should current procurement policy be modified to meet the changes of the 1990's? Descriptive statistics for this part revealed strong agreement or disagreement with the selected questions. Three questions from this part were pre-selected for further analysis because they represented dual-sourcing concepts that must be addressed in the 1990's.

For example, Question #4, "Dual-sourcing of spare parts or modifications will yield positive economic effects in the 1990's," demonstrated very strong agreement. 82% of the implementers agreed or strongly agreed, while only 8% disagreed or strongly disagreed and 10% had no opinion. Further analysis demonstrated no significant difference in the two sub-groups of the implementer population.

Additional analysis was performed to investigate how the implementers responded to other pre-selected questions. There was strong positive correlation with 3 questions and strong negative correlation with 4 questions. For example, respondents that answered positively to Part IV, Question #2, "Defense contractors are so eager for business, and the number of new programs so few, there is no need for government induced competition." answered negatively (-.7) to Part IV, Question #8, "Dual sourcing should continue to be strongly advocated in the 90's in order to maintain the defense industrial base." This enabled us to arrive at our conclusions and also demonstrated consistency in the respondants behavior.

The Financial Effects of Dual-Sourcing

Our goal in this aspect of our research was to see if the government's use of dual sourcing as an acquisition policy affected a firm's financial results and its strategic behavior. To investigate these questions, we used the Standard & Poor's Compustat PC Plus Database. This database is recognized as an industry standard and contains financial data on virtually all publicly traded companies in the United States for the last 25 years.

We initially tried looking at individual companies. However, since many defense contractors are part of diversified companies, we were unable to effectively isolate the business sectors of interest. We then investigated business segments of these defense companies, concentrating on segments which had the most pervasive use of dual sourcing. In particular, we examined aircraft engines, aircraft parts, guided missiles, and shipbuilding. Unfortunately, insufficient business segment data was available from our database to allow for substantive analysis.

We then settled on the approach of examining aggregate data sorted on the appropriate Standard Industrial Classification (SIC) code reflecting the four areas outlined above where we felt dual sourcing had the most impact. Next, we looked at financial performance as reflected in stock prices and returns. We also looked at these aggregates strategic behavior by examining capital expenditures, research and development expenditures, and net property, plant, and equipment. We theorized that these data series would be affected most by a government push toward dual-source procurements. Although we were able to obtain sufficient data, we were unable to draw valid conclusions based upon our analysis.

In retrospect, the fact that we were unable to draw any conclusions about the financial effects of dual sourcing is not really that surprising. Although dual sourcing received lots of publicity, it was never really that significant a technique in the overall scheme of weapon systems acquisition. The aggregate nature of our data masked whatever effects dual sourcing did have on financial performance and company strategic behavior.

CONCLUSIONS

The following conclusions are based in part upon statistical analysis of the data obtained from the "Dual Sourcing in the 90's Questionnaire." Also influencing these recommendations are the opinions written and expressed by the various experts in dual sourcing detailed in the body of this paper. course, the recommendations expressed here also reflect the experiences, opinions, and biases of the authors.

The debate surrounding the estimation of cost savings of dual sourcing is well-documented. The background section of this paper cites a few of the many studies that find significant savings from this acquisition technique. However, different methodologies have produced other studies calling into question the magnitude of these savings. The methodological dispute is better addressed elsewhere. What can be addressed here is the possibility of achieving savings based solely on the presence of the necessary conditions for a successful dual-source program, especially in the 1990's. Our research demonstrated that in many cases, the attitudes and opinions of implementers is different than those of policy makers.

Today's emphasis on improving the quality of weapon systems makes it a key factor in determining dual sourcing's future. If, in order to win a competition, a contractor needs to consider costs, the costs most likely to be curtailed are those which do not directly affect the weapon's operational capability. Benefits from added quality, like those from research and development, are hard to identify or quantify and often result from a substantial investment. Given a choice between the **probability** of some added reliability after a given number of years of service, and the **certainty** of giving up a desired capability, the rational program manager will probably sacrifice the future benefits.

The government and contractors acknowledge the importance of quality. Many books and articles extolling the Japanese emphasis on quality have been written, and some have even been read. The term "Total Quality Management" (TQM) is enshrined in the acquisition hall of fame. Yet, it's much harder to change behavior than it is to adopt a slogan. While words to the contrary are written and uttered, our research shows the prevailing attitude is that dual-sourcing does not add to the quality of weapon systems.

Finally, our research shows a need to address procurement policy for the 1990's. Given the reduced emphasis on defense spending which already characterizes the 1990's, fewer systems will be developed and fewer units will be purchased (Schwartz, 90) Consequently, the candidates for a successful dual-sourcing will be few and far between.

The reputed decline of the American industrial base is by now a well-known story. Equally well known is the decline in the defense industrial base. Since 1982, the number of U.S. firms doing business with the Pentagon dropped from 120,000 to 40,000 (Castro, 90). Many smaller subcontractors have either closed or sought non-defense business. Larger companies like Ford and Goodyear have also shed defense subsidiaries. Dual sourcing, having two companies produce an item rather than just one, seemed a natural solution to the problem of the shrinking industrial base.

However, competition, of which dual sourcing is just one component, has losers as well as winners. The prevailing view about dual sourcing's positive effect on the industrial base is as follows. Company A develops a system and produces the first one or two production lots. Company B, the second source, comes on board along with its own subcontractors. Some of these subcontractors are unique to Company B's team. Thus the industrial base is expanded at both the prime and subcontractor levels. This scenario ignores one simple factor: there is now less business for Company A and its team of subcontractors.

The emphasis in dual sourcing has been on reducing recurring production cost. Hence, the winners from this policy should be the firms with the lowest production cost. The losers should be those inefficient firms with the highest production cost. On the surface, this result looks beneficial to both the government and the society. The government benefits by obtaining weapon systems at reduced cost. The society benefits by a more efficient allocation of resources. Everybody wins with the exception of the inefficient, high-cost, initial source, who was used to overcharging the government and reaping large profits.

If only the world were this simple. Unfortunately, reality interrupts this idyllic scenario. Oftentimes, the "inefficient" firm is better at research and development. This R&D firm expands the limits of technology, develops new systems, and provides the much ballyhooed technological edge upon which our military structure depends. They then must stand-by while some other firm, a lower-cost producer, reaps many of the production profits. Is driving competent research and development firms out of the defense industry, and encouraging low-cost assembly firms to remain, really the goal of our acquisition policy? Or is it just another short-sighted attempt to save a dollar today with the cost of many more dollars tomorrow as we must recreate an R&D infrastructure destroyed in the name of competition?

The bottom line to this argument is that the way the acquisition process works makes it seem that dual sourcing expands the industrial base. However, the reality is far different. Losers won't stay in the defense industry indefinitely. They'll close their doors or find other, more profitable, lines of business. This is optimal if based upon a fair competition where production costs can be readily compared. Unfortunately, the current system does not always allow for a fair competition and we can wind up comparing apples to oranges. Since the firm which invests more in R&D and other programs like quality improvement initiatives will appear more expensive (and hence less efficient), it is at a disadvantage to the second source, which avoids incurring certain overhead-type costs. The result, we believe, is the exact opposite desired. The creative firm, the firm which expands technology, is driven out and replaced by firms specializing in production. Innovation and future capability are lost. Is this what we want? Will this provide the weapons we need to defend this country with the reduced force stucture of the 1990's?

RECOMMENDATIONS

The primary goal of dual sourcing was to reduce the cost of weapon systems. Secondary goals included improvements in quality and expansion of the industrial base. If a policy fails to achieve its goals, it should at the minimum be examined; and perhaps discarded.

The 101st Congress took a major step in reducing the scope of dual sourcing as an acquisition stategy. Section 805-Competitive Alternative Source Requirement, of the FY 1991 Defense Authorization Act (Public Law 101-510) (AIA 90, p.8) eliminated the statutory preference for dual sourcing. This change will force dual sourcing to stand or fall on its merits given the particulars of each major acquisition. A landmark Rand Corporation study on acquisition reforms arrived at similar recommendations several years earlier(Rich and Dews 86, pp. 49-50). Also, the Assistant Secretary of the Air Force for Acquisition, Mr. John Welch Jr., asked all Program Executive Officers and Product Division Commanders to review all dual-sourced programs to see if the could be more efficiently procured through other means (Welch 90, p.1). Given the realities of procurement in the 1990's, it is our belief that dual sourcing will most often **NOT** be the proper acquisition strategy.

Finally, through our analysis, we can answer our three research questions. First, do the attitudes and opinions of defense competition "policy implementers" differ from those of "policy makers" as concerns dual sourcing? Clearly, the answer is yes. But, and it's a big but, as the results of the 101st Congress make clear, the gap is narrowing. The so-called conventional wisdom is moving away from the idea that dual sourcing is **one** of the cure for the ills of the acquisition process. Rather, the policy makers and the implementers seem more in agreement that dual sourcing makes sense only given the strict conditions of a long production run, low initial investment costs, and low technology transfer costs. In other words, look at dual sourcing on a case-by-case basis; not as a blanket policy.

Second: Does dual sourcing enhance the quality of major weapon systems? This question is a lot harder to answer. In fact, there may not be one answer to this question. There is no inherent incompatibility between dual sourcing and quality. However, it seems whenever the government uses any form of competition for production units, low cost seems to be stressed at the expense of everything else, including quality.

Third: Should current procurement policy be modified to meet the changes of the 1990's? The answer is clear: an emphatic YES! And, as we have already seen, the policy is changing and will undoubtedly continue to change. What is important here is that the policy changes reflect the changes in the environment. All too often in the past, the DoD has practiced "Management by Fad" to the detriment of wise acquisition policy. Policy makers should consult with policy implementers to ensure that in the 1990's, acquisition policy reflects the reality of our changing defense needs.

In short, dual sourcing probably still has a role to play in the defense acquisition process. But this role is clearly a cameo, limited to unique circumstances having particular characteristics. It is our hope that in the 1990's, policy makers do not repeat their historical tendency to search for the Holy Grail to eliminate all acquisition problems with one policy pronouncement. Rather, we hope for a policy which reflects the environment of the times and builds on the acquisition system's current strengths, which clearly outweigh the weaknesses.

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Improving the Requirements Process in Acquisition

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Abstract

Weapon systems acquisition is a very complex process that takes too long, costs too much, and too often provides systems lacking in functionality, supportability, or some combination of the two. There have been a series of efforts designed to improve the process, the most recent being the Total Quality Management (TQM) initiative, and the engineering aspect of TQM, concurrent engineering (CE) or Integrated Product Development (IPD) as we refer to the DoD implementation of CE. CE is the systematic application of systems engineering principles to the parallel development of products and their related manufacturing and support processes. Though much of CE emphasis is on industry where the weapon systems are actually designed and built, the foundation for those weapon systems is the needs and reequirements as determined by the government and provided to industry in the form of specifications and contractual work documents. CE, or IPD, tools and techniques must be applied to the government requirements process to realize the potential payoffs. The Requirements Analysis Process In Design (RAPID) is a research initiative within the Armstrong Laboratory to improve critical aspects of the DoD weapon systems acquisition process, specifically aimed at improving the DoD requirements process. This paper describes related research in the requirements area and proposes a function/perspective model of the requirements process providing a more dynamic characterization of the requirements process. A suite of tools is described, which when combined with expert and knowledge-based systems, realize the proposed model. Potential benefits from a RAPID environment as envisioned is then discussed.

Introduction

The definition, development, and fielding of Department of Defense (DoD) weapon systems is a very complex process, both in terms of weapon system complexity and acquisition process complexity. The result of this complexity is that the development of a weapon system capability takes too long, costs too much, and all too often falls short of the originally sought after capability.

The defense acquisition problem is well documented and often seen as part of a larger DoD management problem. There have been a number of initiatives to improve, not only the acquisition and development process, but the management structure and processes within which acquisition and development efforts must function. Among the more recent initiatives are Acquisition Streamlining, Affordable Acquisition Approach, the Blue Ribbon Commission on Defense Management (Packard Commission), and the 1989 Defense Management Review. Though none of these initiatives solved the entire problem, each left its mark in some way. Each also contained similar themes, among them, increased program stability (budgetary and functionally), shorter reporting chains, better management principals, and better definition of the requirements for the weapon system.

An essential element for success in each initiative was, and remains, the underlying need for cultural change. Cultural change is the most difficult element to realize and often the element most neglected. Cultural change is also the most time consuming element. Changes to regulations, guidelines, or procedures might disrupt the current process for a time, but a culture is the sum total of the individual beliefs, perceptions and actions as well as the "corporate identity" of the organization. Only time, and much focused effort, can change such a culture.

Total Quality Management

One key thrust of the Total Quality Management (TQM) initiative is this time consuming process of cultural change. Adopted by DoD in 1988, TQM was soon the "way-of-life" approach to the acquisition business [Costello, 1988]. Basically, TQM grew out of increasing industry concern over American industrial competitiveness and America's apparent slip in relation to other leading industrial nations. Loss of market share, such as in copiers, or even entire industries, such as video recorders, caused industrial leaders to step back and study the success factors among their competitors. Quality in products and processes stood out as a critical success factor. As a major customer, and supplier, to the American industrial base, the DoD has taken an active role in industrial competitiveness by adopting and promoting quality concepts and philosophies such as found in TQM. TQM has other desirable components besides industrial competitiveness. Improved organizational communications, fewer levels of management and more efficient organizational processes are attractive solutions to any problems within the DoD management structure. Thus, while this paper views TQM only from the acquisition standpoint, TQM really is a vital initiative nearly DoD-wide.

Concurrent Engineering

Applying quality to the industrial and government organization requires improving the manufacturing and design operations. The engineering aspect of TQM is concurrent engineering (CE). Just as TQM was adopted by DoD acquisition, so too was CE adopted by the DoD acquisition community. There must however, be some distinction between CE for the industrial design and manufacture community and CE applied to the DoD acquisition efforts. The distinction we make here is to refer to CE within DoD as Integrated Product Development (IPD).

The best known and surely the most cited definition of CE is that definition provided by the Institute for Defense Analyses (IDA) [Winner, et al. 1988]:

> Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.

Basically, CE is systems engineering as systems engineering was originally envisioned. Technology has made possible those aspects of systems engineering previously deemed impossible to accomplish [Tetmeyer, 1990]. CE-based initiatives in advanced design environments, integrated databases, and analytical techniques are critical to CE success, particularly with increasingly complex designs for increasingly capable systems. Just as important though, are human-centered initiatives such as group support technology, multi-functional and collocated work teams, and human factors engineering of both the product design and the design process. Such initiatives are very applicable to industry since it is industry, not the government, that designs, builds, and manufactures the physical weapon system and equipment.

A better definition of CE, one that accounts for the concept of IPD (CE applied to government efforts) is that it is a philosophy of product design which emphasizes: (1) coordination between interdependent design activities, (2) better support and tracking of product evolution, and (3) simultaneous consideration of all elements of the product life cycle. This definition better captures what is required for IPD. Since the DoD doesn't produce the actual (physical) weapon system, the product of DoD IPD efforts can be thought of as the requirements for the weapon system. Thus, the product of CE (industry efforts) is the physical realization of the requirements, the weapon system or equipment. The product of all efforts is the system or equipment.

TQM, CE, IPD, or for that matter any improvement initiative have similar goals. These are to: (1) improve quality, (2) reduce cost, and (3) reduce development time. These are also desired goals for all acquisition efforts. The foundation for any weapon system acquisition effort is the needs and requirements upon which the effort is initiated and planned. Consider for example, the design and construction of a building. The structure must reside on an adequate foundation otherwise the entire building crumbles. The best materials, tools, and techniques can be employed but will not avert a disaster caused by a poor foundation. Similarly, in weapon system acquisition, the best design tools and techniques can not truly achieve the aforementioned goals unless the needs and requirements, the foundation for the effort, are adequately described. This foundation is built by the government and provided to industry in the form of specifications and contractual work documents. Industry builds the weapon system based on these foundation documents.

The Unified Life Cycle Engineering (ULCE) initiative had similar goals and recognized the need to improve up-front design efforts. A precursor to CE, ULCE envisioned an advanced computing environment with which to consider product producibility and supportability simultaneously with cost, schedule, and performance. In a series of reports, the ULCE program investigated various aspects of the product design process. These efforts influenced design efforts such as the McDonnell Douglas LHX program [Meyer, 1990], the AFHRL Reliability, Availability, and Maintainability in Computer Aided Design (RAMCAD) program (and similar industry initiatives), small business research, and academic research such as the Computer Aided Life Cycle Engineering (CALCE) project at the University of Maryland. ULCE targeted the early design stages advocating advanced computer techniques. A weak area in ULCE efforts was the lack of emphasis on design team efforts and the targeting of industrial design efforts seemingly at the expense of the government's role in the design process. Only later during ULCE efforts were human-centered factors considered along with better requirements definition efforts by the government.

Requirements Process

IPD must find a home in the government requirements process to realize the potential payoffs promised by CE and IPD. The government product is the needs and requirements documents. A lack of discipline and sincere emphasis on the requirements process has existed. Additionally, the requirements process can be characterized as a manual, paper-based process. But clearly defining weapon system needs, characteristics, and design requirements are keys to successful design and acquisition efforts. As such, there is a tremendous potential for improving the overall weapon systems acquisition process by simply improving the government's requirements process.

Consider Figures 1 and 2 from Huthwaite and Schneberger [1989]. Figure 1 characterizes the influence early design decisions have on life cycle cost even though there has been little actual expenditure of money. Figure 2 depicts the rising cost of bad (or simply incorrect) decisions. The "Escalator Effect" is one in

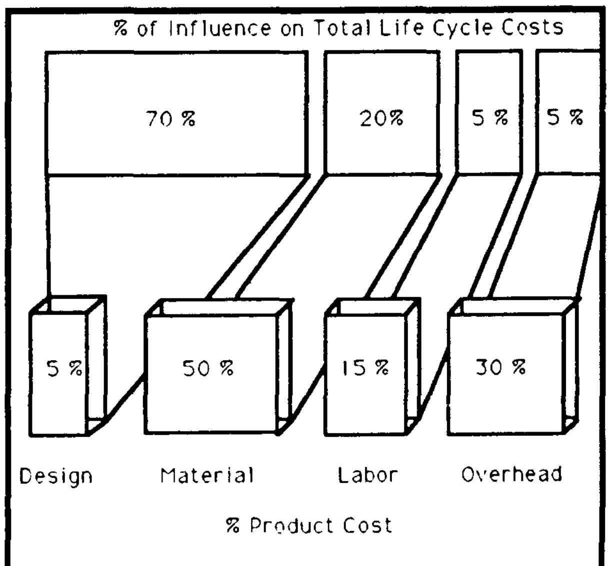

Figure 1: Influence of Product Cost on Life Cycle Cost

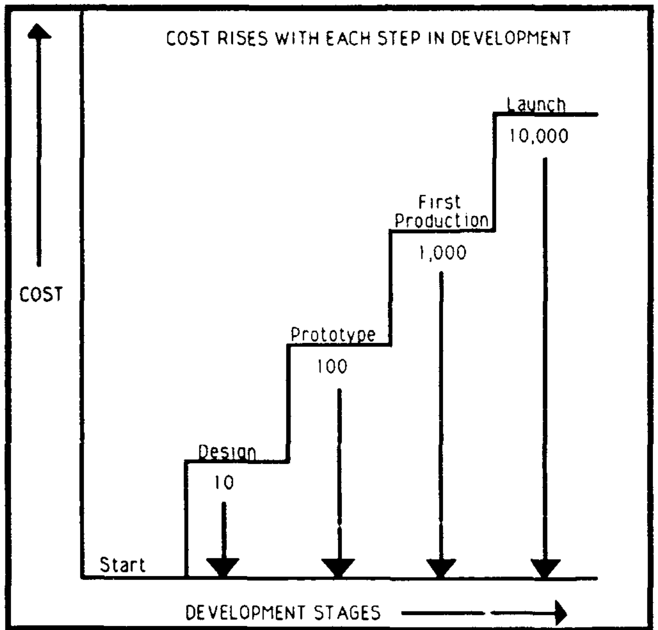

Figure 2: Escalator Effect of Cost of Change

which the cost of change increases over time, though not necessarily at the proportions depicted in Figure 2. These change costs can be avoided by making better decisions early in the design-decision process.

What exactly is a weapon system requirement? From the Air Force Institute of Technology (AFIT) [AFIT, 1990], a requirement is "the need or demand for personnel, equipment, facilities, other resources, or services, by specific quantities for specific periods of time or at a specified time." A required operational characteristic is "a system parameter (or set of) that are primary indicators of the system's capability to be employed to perform the required mission functions, and to be supported." A required technical characteristic is "a system parameter (or set of) selected as primary indicators for achievement of engineering goals. These may not be direct measures of, but should always relate to the system's capability to perform the required mission functions, and to be supported." [AFIT, 1990].

This set of definitions imply a specified system, parameterized and quantified. Further, they imply a somewhat static environment in which the requirements are set and then remain relatively stable. Not until full-scale development will such a set of requirements become available [Ferguson and Hertz, 1990]. The Pymatuning [1988] study on CE labeled this characteristic of requirements as a "lack of clarity in the definition of the requirements" citing the characteristic as one of two inhibitors within the requirements specification process. This inhibitor "results in an inability to define real requirements in the early concept and design definition phases of a program." Part of this inability stems from the inability to adequately perform trade-off studies among competing requirements [Pymatuning, 1988].

The terms requirements and need seem synonymous. A need is "something useful, required" while a requirement is "something needed; a necessity." Must there be a distinction? Our research indicates there must be a difference, albeit a subtle difference. Weapon systems are developed to meet operational threats. Operational threats are derived from the National Security Strategy of the United States. As this strategy permeates through the DoD, operational planners eventually uncover a deficiency, or operational "need" to counter an operational scenario. This need is met by existing capabilities, tactic changes employing existing capabilities, or the development and acquisition of new systems (modified or newly developed).

For acquisition efforts, the need undergoes a sequence of redefinitions and transformations referred to as product design and development. This sequence produces an increasingly exact set of limiting conditions (requirements) on the needs that must be met. The end use system should satisfy the final set of requirements defined to meet the previously defined operational need. We refer to the aggregation of all the requirements as the **requirements set** for the weapon system.

This sequence is the weapon system requirements process, a key component of the DoD acquisition process. Air Force Regulation 57-1 states that the requirements process "begins with identifying operational needs and continues throughout the acquisition process and the life of the system." An incredible amount of scrutiny, oversight, and attempted improvements have been applied to the acquisition process. All are attempts to make the acquisition process more streamlined, business-like, and more efficient. For the most part, the efforts have created an acquisition process bogged down in regulations and guidelines, a process whose estimated time-span is over 20 years if all rules and regulations are properly followed. The requirements process portion of the acquisition process has also received more interest of late. Numerous papers and reports have examined the process and proposed changes to the process. While not reviewing each contribution in detail, the next paragraph describes six contributions.

Both the Packard Commission and the Goldwater-Nichols Act sought to improve the requirements process-that is, DoD's efforts to define military needs, their links to national strategy and deficiencies in existing capabilities, and the characteristics of specific systems to meet those needs [Cheney, 1989]. Kent [1989] proposes a streamlined approach for force planning, advocating a top-down approach whose key "is the formulation of operational concepts to provide the link between development and acquisition programs and operational tasks." Kent's approach was expanded by Miller [1990] who described Quality Function Deployment (QFD) as a technique to implement the framework of "strategy-to-task."

Ferguson and Hertz [1990] also refer to the Kent framework, but draw a distinction between the macro-level and micro-level views of requirements. A macro-level view is based on operational requirements considered at a very high level of DoD management. The micro-level view is the weapon system level view, where hardware is defined to meet mission needs. How you view a requirement depends upon where you sit in the organizational hierarchy. Fluctuation between these views is a cause of problems. Ferguson and Hertz also discuss an improved model of the requirements process as it fits into the Air Force planning process. Stanley and Birkler [1986] discuss ways to improve the suitability of weapon systems. Their approach is to better define requirements, relate these requirements to the mission needs, and link the requirements to the testing verifying the system capability. Their study reviewed early requirements documents (primarily Statements of Operational Needs, SONs) and recommended better methods for maintaining requirements consistency, quantifying requirements, and implementing more thorough testing.

The findings and recommendations of each contribution to the literature can be generalized. Though the subsequent list (by no means complete or all-inclusive) is derived for the requirements process, some entries apply to improving the overall acquisition process. In general, there should be:

- Better discipline throughout the process,
- Streamlined reporting channels,
- A link between acquisition efforts and operational tasks (a strategies to task link),
- Improved baseline maintenance and consistency among and between acquisition documentation to include audit trails,
- Explicit consideration of life cycle support issues early in the process,
- A multi-disciplined team approach to the definition of the requirements for new systems,
- Generation of more system alternatives yielding more robust designs,
- Enhanced role of test and evaluation in the requirements and acquisition process, and
- Increased program stability in program budget and system requirements.

Each of the above findings offer solutions to problems inherent in the requirements process. Actual manifestations of increased emphasis on requirements can be found in "ility" efforts which focus on a single class of functional (or support) requirements, sometimes at the expense of other related requirements. For example, consideration of reliability on par with cost and schedule will certainly yield systems with higher reliability. However, often the maintainability of that same system is apt to suffer. There is no integration of the "ility" stovepipes into a system vie...

The best way to improve the weapon system requirements process is through a combination of all the general findings. The best solution will see cultural change improving discipline and accountability in the process, process changes at the macro-level and micro-level, and tools that provide for more complete and consistent requirements sets as well as linkages among, and between, the requirements. As first stated, cultural change is the hardest piece to affect in any improvement effort. It meets the most resistance and takes the longest to show true changes. Further, when the culture has changed, how are you sure? If the change is evolutionary, it might be very hard to notice the change. During the transition period, personnel must still accomplish their tasks. Productivity and effectiveness in the requirements process can be achieved through appropriate use of decision support computer technology and supporting methodologies while efforts such as:

- Closer ties between contractors and government,
- Changes to the sources selection process, and
- Increased discipline and clear accountability in design,

take longer to realize due to the reliance each has on cultural (and legislative) change.

True efficiencies require cultural change, increased discipline, better tools and techniques, and integrated "ility" considerations. The Requirements Analysis Process In Design (RAPID) project takes on the tools, techniques and integrated "ility" portions of the solution.

Requirements Analysis Process In Design (RAPID) Project

RAPID is a research and development project whose goal is to produce a decision support environment for weapon systems acquisition and development. The RAPID project seeks improvements to the weapon systems acquisition process by improving the weapon systems requirements process. The hypothesis underlying the project is that decision support computer tools, when coupled with supporting methodologies and techniques, enable the analyst to work more productively and effectively. Thus, RAPID targets the micro-level requirements process primarily, with secondary concerns at the macro-level. The micro-level process supported by RAPID consists of three functions:

- requirements definition,
- requirements analysis, and
- requirements management,

delineated by three perspectives:

- functional,
- hierarchical, and
- managerial.

For convenience, we define Analyst A as one currently involved in the requirements process for System X. We purposely avoid defining exactly how Analyst A is involved in System X definition since this proves useful in describing the functions/perspectives model of the requirements process.

At any point in time, Analyst A is working one of three functions for System X. While in the requirements definition function, he is determining goals which the end system must achieve, defining a system need or requirement, or defining further limiting design constraints. Analyst A can analyze the requirements. In this role, he is conducting tradeoff analyses, investigating interrelationships among requirements, or gaining a deeper understanding of the current requirements set. Analyst A is doing this for any number of reasons, among them investigating reasons for operational deficiencies, redefining constraints, decomposing requirements into further detail, or fine tuning requirements for their system-level impact. Finally, Analyst A can manage the requirements, which involves monitoring compliance, ensuring audit trails on the requirement's evolution, documenting changes, etc. A decision support environment such as RAPID must be capable of dynamically adapting to these functions as the user of RAPID moves among the functions.

Analyst A also overlays a particular perspective on the requirements. This perspective is the manner in which the analyst views the data. For instance an aircraft designer may be interested in sizing the fuselage. He will examine equipment layout with a different purpose than would a maintainability engineer. The designer wishes to reduce volume to decrease the fuselage size while the engineer will seek to increase volume, if necessary, to accommodate efficient maintenance technician access to the equipment.

The functional perspective addresses examination by a particular functional area, such as an "ility." The examination is restrictive in that there is little concern for system-level impacts. In actual practice this is not the case, but for purposes of independence, this perspective concentrates just on the single functional concern. The hierarchical perspective examines the design at various levels of system decomposition and design detail. The hierarchical perspective allows viewing of the design at various levels of detail examining relationships up and down the design decomposition. The managerial perspective must allow for aggregation of data for various purposes depending upon where one sits in the DoD acquisition bureaucracy.

Taken together, functions and perspectives provide a dynamic model of the micro-level requirements process. The challenge is to develop a RAPID environment to accommodate this model of the requirements process. One approach is to define a suite of tools and techniques that adequately cover the model. Such a suite may consist of:

- Need identification tools,
- Analysis/tradeoff of requirements tools,
- Requirements traceability tools,
- Test planning and risk analysis tools.

Needs identification tools provide capabilities to characterize mission scenarios, examine current inventory capabilities to counter the scenarios, and determine operational deficiencies. Such tools also support the definition of support requirements to meet mission scenarios thus improving the robustness of weapon systems solutions to mission needs. Later in the acquisition and development process, such identification tools play a role in examining alternatives should there be a change in program development emphasis.

Analysis and tradeoff tools enable timely, accurate, and more informed decision making early in the design decision making process. As needs and requirements are determined, they must be examined from a system point of view. Each system parameter must be established to aid overall system performance. Tools, such as expert systems or simulation programs, aid in this tradeoff decision process. Additionally, lessons learned, standards, and guidelines can be integrated into the system and evoked when required providing a template from which to tailor the requirements set.

Requirements traceability tools allow users to manage complexity in evolving weapon systems. Such tools establish explicit relational links among the requirements of a system. These relationships are defined among functional requirements, between functional subsets of requirements, and span the design decomposition. The power of such tools is in their ability to manage the evolving design in such a way as to ensure correspondence between the customer requirements (the need for the weapon system) and the final system parameters and configuration. Additionally, these tools provide a Requirements Correlation Matrix (RCM) capability to provide assistance in the evolution of needs documents and a Baseline Correlation Matrix (BCM) capability to promote consistency among program documentation.

Test planning and risk analysis tools assist the program management staff in program oversight efforts. Test plans should correlate to original weapon system needs, thus reducing unnecessary tests, highlighting gold-plating, and depicting needs and requirements not built in to the system. Risk management tools provide insight into the effects of failing to meet system parameters or constraints. For instance, if a system fails to meet specified weight constraints, a program manager will want to know the impact such a situation produces. A risk management tools helps answer such questions.

The RAPID vision then is to develop prototype decision support tools that support the function/perspective model of the requirements process by providing an integrated suite of tools to define, analyze, and manage weapon system requirements. This integration effort will require use of expert system techniques, knowledge base technology, graphical user interfaces to efficiently display the information, and robust data base structures modeled after the relational and object-oriented paradigms. Users will employ graphics to ease data entry and data viewing tasks. Output will take the form of required documents (i.e., RCM, SON, specifications) or tailored reports (i.e., audit support reports, change impacts reports). The actual user will vary depending upon the particular point in time within the acquisition process and where that person resides in relation to the acquisition effort and the bureaucracy. Very early, during mission area analyses, the typical user will be a MAJCOM force planner interested in how to meet certain scenarios and whether new capabilities or tactics are required. Over time, the users are Product Division advanced planners, Special Project Office personnel tasked with developing the contractual documents, or SPO personnel tasked with managing the development effort. The key to RAPID success will be its flexibility in managing and maintaining the consistency of the requirements set for a particular development and acquisition effort.

Such an environment as envisioned by the RAPID research project could bring potentially significant savings and improvements to the weapon system acquisition process.

Benefits of RAPID

More thorough investigation of alternatives. Integrated systems increase user productivity thereby allowing users do the job more rapidly. Knowledge-based systems increase user efficiency as well as productivity as users examine more alternatives in a shorter amount of time. Use of RAPID during early conceptual development efforts will enable exploration of more alternatives to meet specific mission needs.

More robust and flexible alternatives. The challenge facing the military is vastly different and more dynamic than in years past. Smaller, more capable forces must meet challenges in a diversity of elements and missions. This situation will continue in the future. For a good example, examine the threat described by Rich, Stanley, and Anderson in a 1984 RAND Corporation report [Rich, 1984]. Though today we face a different threat, their conclusion for accommodating the dynamic threat is still valid. The DoD needs more robust weapon systems to accommodate the ever changing threat. The RAND researchers [Rich, 1984] recommend analytical tools and techniques to evaluate requirements tradeoffs. These tools are required to propose and define weapon systems that are robust enough to deploy rapidly, deploy over long distances, and operate in austere environments. RAPID brings more knowledge to bear on the design tradeoff process earlier in the process allowing such considerations to occur.

More complete definition appropriate to the development phase. As Figure 2 depicts, the best way to save the cost of change is to avoid the change altogether. Integrated, knowledge-based tools provide a level of completeness in definition efforts not possible with manual methods. Current reliance on functional experts with experience on similar systems is relieved with the use of expert system technology. Further, concepts such as evolutionary requirements definition are easily incorporated as operating constraints within a RAPID environment.

Better consistency in the requirements set. An information base within RAPID will store a single instance of a particular requirement and establish links to each program document containing that requirement. Updates are made one time and ripple through the documentation in a complete and timely manner. Further, changes to a requirement can be viewed with respect to the impact such a change will have on the entire program.

Better cost versus performance analysis. As the RAPID knowledge base grows so to should it's predictive power particularly in deriving cost and resource estimating relationships among program needs and requirements. Too often early cost estimates, made with incomplete information, become banes to the program as more information is obtained and early estimates are shown as inaccurate. Better estimates either come later in the process or come as a result of better information on past efforts. RAPID can become a vehicle to obtain and employ past information for future system resource estimation.

Enhanced definition by virtual, multi-functional teams. Advanced computing platforms and communications networking technology provide for the "virtual" tiger team. In such teams, team members are collocated via computer links while being physically separated. A RAPID system existing within such Group Support Technology (GST) applications will significantly decrease the time required to define new capabilities and new systems while increasing user satisfaction and their sense of ownership with the system definition. Rather that involving the required personnel by mail, or in face-to-face meetings, a computer meeting provides the required communication quickly and effectively.

Decrease cost, decreased schedules and increased quality. A more efficient, complete, and accurate depiction of the mission need and corresponding weapon system requirements will help achieve these goals. Results include fewer engineering changes, better tracking of design parameters to system need, quicker definition phases, and better integration of functional area concerns into the overall system requirements set.

Conclusions

To realize TQM, CE, and IPD goals, DoD must not only advocate industry adoption of TQM and CE, DoD must incorporate TQM and IPD. Adequately adopting these philosophies have macro-level and micro-level issues that must be resolved, many of which are cultural issues by nature. Cultural change is the hardest change to affect and requires the longest amount of time. While the culture is in transition, weapon systems acquisition efforts continue. Thus, we must improve current capabilities to enhance current acquisition efforts.

RAPID is one such micro-level research program. Realizing the tremendous emphasis TQM has on properly defining requirements, RAPID seeks to develop technologies and techniques to create an environment for improving the definition, analysis and management of weapon system requirements. RAPID thus seeks to improve the foundation efforts for the design and development of weapon systems.

The vision of RAPID is to integrate available techniques with expert systems, knowledge bases, advanced data bases, and computer communications technology to provide the end-user a useful tool. The potential benefits of such a system are tremendous. Interfacing RAPID to other decision support system efforts, such as the Program Manager Support System (PMSS) at DSMC promise turn-key systems of tremendous value to future weapon systems design, development and acquisition efforts.

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APPLICATIONS OF FUZZY LOGIC TO DEFENSE ACQUISITION

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ABSTRACT

First introduced in 1965 by Lofti Zadeh, fuzzy logic allows for a mathematically precise handling of inexact or vague data. Although criticized on both theoretical and empirical grounds, many technical papers have rigorously advanced the field, applying it to automata theory, system theory, decision theory, switching theory, and pattern recognition. Fuzzy logic is commercially useful in the design of computer controller boards, computer processors, fuzzy peripherals, and fuzzy ROMs (read only memories). The Japanese are using fuzzy products in over 80 successful applications.

The ability of fuzzy logic and fuzzy set theory to handle vague and inexact data can be directly applied to defense acquisition. By applying the mathematical rules of fuzzy logic, decisions and risks can be evaluated from a common base. This enables the acquisition project manager to maintain better the all important cost, system effectiveness, and schedule balance. Although there may seem to similarities of fuzzy logic to probability and statistical analysis, this theory is different in that it handles possibilities vice probabilities. Many risk and management decisions can and should be decided using classical probability methods, statistical analysis or utility theory. Fuzzy logic cannot replace these tools, it only represents an additional aid in acquisition management.

This paper introduces the basics of fuzzy theory and show its use in three examples:

1. Using fuzzy logic to evaluate subjective company performance information in order to refine a classic utility value and decision tree analysis.

2. The use of fuzzy logic to model the dynamics of group decision making in order to predict the outcome of a group decision.

3. The use of fuzzy linear programming to predict cost overruns.

Its purpose is to expose the defense acquisition community to an additional tool with which to manage scarce resources.

INTRODUCTION

First introduced in 1965 by Lofti Zadeh, fuzzy logic allows for a mathematically strict and rigorous handling of inexact or vague data. A professor at the University of California at Berkeley, Zadeh asserts that "Fuzzy logic is the logic of approximate reasoning, with [traditional] precise reasoning as the limiting case." Although criticized on both theoretical and empirical reasons, the theory has continued to be developed. Technical papers by Zadeh, Ramesh Jain of the Indian Institute of technology, and others have rigorously advanced the field, applying it to automata theory, system theory, decision theory, switching theory, and pattern recognition to name a few. Two researchers at AT&T Bell Laboratories, Hiroyuki Watanabe and Masaki Togai, collaborated in the design of a fuzzy logic controller board in 1980. Two Japanese companies, Mycom Inc, and Omron Tateisi Electronics Co., will be offered dedicated fuzzy controllers to the U.S. market in 1990. Other fuzzy products include fuzzy computer processors, fuzzy peripherals, and special fuzzy ROM (read only memory) that hold the proper fuzzy response, according to the programmers rules, to any given input situation.

" These fuzzy products have, to date, been used in 80 successful applications in Japan, says Michio Sugeno, professor of engineering at Tokyo Institute of Technology. A subway system in Sendai is controlled by a fuzzy processor (in lieu of an engineer) and reportedly affords a smoother ride than any human conductor ever provided. Tokyo-based Yamaichi Securities Co. Ltd. is using a fuzzy system to pick stocks for a special portfolio." [1]

Fuzzy expert systems have also been designed to make management-level business projections, control output from power stations, economize on automobile gas consumption and refine manufacturing process control.

In the United States fuzzy is only now becomming popular. After initial sucessful use by NASA for space shuttle positioning, commercial companies are now jumping on the fuzzy bandwagon. Olympus, Canon and Fisher are using fuzzy in their 8mm camcorders. Panasonic uses Fuzzy logic as part of its stabilization feature, eliminating the shakey picture inherent in home videos.[2]

"[Fuzzy logic] was all the rage at last summer's Consumer Electronics Show in Chicago, and industry pundits expect that the small trickle of video products on the market now incorporating the technology will become a tidal wave over the next few years."[3]

SO, WHAT IS FUZZY?

Fuzzy set theory, which underlies all fuzzy applications, generalizes the characteristics to which it is applied. For example, let's discuss the set of "women heights." The problem is in deciding what constitutes a "tall" versus a "short " woman. For this example all females below four feet are described as "very short" while women over seven feet are assumed "very tall." We can now use fuzzy set theory linguistic hedges to categorizes women that fall between being a member of the "very tall" and "very short" set of women heights.

First the fuzzy set "universe of discourse" must be determined. This can be described as the range of absolute values through which uncertainty exist. In this case the obvious universe of discourse is from 7' down to 4'. The linguistic hedges we will use to describe women in this range are:

VERY TALL	VERY SHORT
TALL	SHORT
RATHER TALL	RATHER SHORT
SORT OF TALL	SORT OF SHORT

AT LEAST AVERAGE
AT MOST AVERAGE
AVERAGE

Not arbitrary, these linguistic terms are derived from allowable liguistic terms developed for fuzzy set analysis. Each term has a specific mathematical function describing set membership as the universe of discourse is traversed. This allows the construction of a fuzzy table of membership for women across the universe of discourse of 7' to 4'. (TABLE 1).

With the use of a TABLE 1 we can now construct a five point fuzzy set descriptor of each istic hedge.

VERY TALL
{(1,7),(.86,6.5),(.14,6),
(.03,5.5),(01,4.5),(0,4.5),
(0,4)

TALL {(1,7),(.93,6.5),(.37,6),
(.16,5.5),(.08,5),(.05,4.5),
(.03,4)}

RATHER TALL
{(.47,7),(1,6.5),(.3,6),
(.07,5.5),(.03,5),(.01,4.5),
(.01,4)}

SORT OF TALL
{(.11,7),(.6,6.5),(1,6),
(.27,5.5),(.06,5),(.03,4.5),
(.01,4)}

AT LEAST AVERAGE
{(1,7),(1,6.5),(1,6),(1,5.5),
(.18,5),(.04,4.5),(.01,4)}

AVERAGE
{(.01,7),(.04,6.5),(.2,6),
(1,5.5),(.18,5),(.03,4.5),
(.01,4)

AT MOST AVERAGE
{(.01,7),(.04,6.5),(.2,6),
(1,5.5),(1,5),(1,4.5),(1,4)

SORT OF SHORT
{(.01,7),(.03,6.5),(.07,6),
(.27,5.5),(1,5),(.6,4.5),
(.11,4)}

RATHER SHORT
{(.01,7),(.01,6.5),(.03,6),
(.07,5.5),(.33,5),(1,4.5),
(.47,4)}

SHORT
{(.03,7,(.05,6.5),(.08,6),
(.16,5.5),(.39,5),(.93,4.5),
(1,4)}

VERY SHORT
{(0,7),(0,6.5),(.01,6),
(.03,5.5),(.15,5),(.86,4.5),
(1,4)

TABLE OF MEMBERSHIP

WOMEN HEIGHTS
(feet)

LINGUISTIC HEDGE	7	6.5	6	5.5	5	4.5	4
VERY TALL	1	.86	.14	.03	.01	0	0
TALL	1	.93	.37	.16	.08	.05	.03
RATHER TALL	.47	1	.3	.07	.03	.01	.01
SORT OF TALL	.11	.6	1	.27	.06	.03	.01
AT LEAST AVERAGE	1	1	1	1	.18	.04	.01
AVERAGE	.01	.04	.2	1	.18	.03	.01
AT MOST AVERAGE	.01	.04	.2	1	1	1	1
SORT OF SHORT	.01	.03	.07	.27	1	.6	.11
RATHER SHORT	.01	.01	.03	.07	.33	1	.47
SHORT	.03	.05	.08	.16	.39	.93	1
VERY SHORT	0	0	.01	.03	.15	.86	1

TABLE 1

WHile the usefullness of this information with respect to women heights may be questionable, the following examples will demonstrate how fuzzy can aid in everyday procurement decisions.

A SIMPLE FUZZY EXAMPLE [4]

Let's suppose you were going to bet on a race between 3 horses. The horses' best and worst times with discriptive remarks are shown in Figure 2.

HORSE STATISTICS

HORSE REMARKS	WORST TIME	BEST TIME
1	2:10	1:35
Possibility of 1:35 time <u>sort of low</u>		
2	2:15	2:02
Possibility of running a 2:00 time <u>very high</u>		
3	1:55	1:47
Times are always about <u>average</u>		

There is an infinite number of times that each horse could run. The object is to identify the most possible time. Because of the nature of horse races, probability theories are inappropriate. Past performances are not accurate predictors of future capabilities nor do odds reflect the horses capability.[5] The linguistic hedges underlined in the remarks section can be used to determine the most possible times for each horse.

In evaluating Horse 1 its universe of discourse is from his maximum time of 2:10 to the minimum of 1:35. Although it is possible for the horse to run times outside this range, the possibility of this occurring is small. The infinite number of possible ties can be represented by selecting five time points for the fuzzy analysis.

Point	Time (mins)	Time (secs)
1	2:10.00	130
2	2:01.25	121.25
3	1:52.50	112.5
4	1:43.75	103.75
5	1:35.00	95

By using a table of membership and the fuzzy description "sort of low" membership values for each point within this range can be determined. The resultant five point fuzzy set description of Horse 1 is:

Point	"Sort of Low" Value	Time
1	.11	130
2	1.00	121.25
3	.27	112.5
4	.04	103.75
5	.01	95

or in fuzzy set notation:

Horse 1
{(.11,130),(1.0,121.25),
(.27,112.5),(.04,103.75),
(.01,95)}

By using the "very high" and "average" membership descriptions,

Horse 2
{(0,135),(0,131.75),
(.03,128.5),(.4,125.25),
(1,122)}

Horse 3
{(.01,115),(.08,113),(1,111),
(.08,109),(.01,107)}

Next the maximizing sets for each horse is determined. This represents each horse's membership in the entire range of times. The "Y" set of all times is the union of all possible time sets:

Horse 1
(130,121.25,112.5,103.75,95)

Horse 2
(135,131.75,128.5,125.25,122)

Horse 3
(115,113, 111,109,107)

Y=(135,131,130,128.5,125.25,
122,121.25,115,113,112.5,
111,109,107,103 .75,95)

Y_{max}, 135, is divided into each horse's time set to determine its grade of member-ship to Y. For example Horse 1's first time of 130 is divided by 135 resulting in a membership grade of .96. This fuzzy operation, called maximizing sets, yields for each horse:

Horse 1
{(.96,130),(.89,121.25),(.83,1
12.5),(.76,103.75),(.7,95)}

Horse 2
{(1,135),(.97,131.75),(.95,128
.5),(.92,125.25),(.9,122)}

Horse 3
{(.85,115),(.83,113),(.82,111)
,(.80,109),(.79,107)}

The minimum membership values of each time for each horse then determines the fuzzy optimum set for that horse. This operation, called the minimizing, yields:

Horse 1
{(.11,130),(.89,121.25),
(.27,112.5),(.04,103.75),
(.01,95)}

Horse 2
{(0,135),(0,131.75),
(.03,128.5),(.4,125.25),
(.9,122)}

Horse 3
{(.01,115),(.08,113),
(.82,111),(.08,109),(.01,107)}

The maximum membership values represent the optimum performance for each horse:

Horse 1 (.89,121.25)
Horse 2 (.9,122)
Horse 3 (.82,111)

Horse 1 has a .89 possibility membership of running a 2:01.25 (121.25 seconds) time, horse two a .9 possibility of a 2:02.00 and horse 3 a .82 possibility of 1:51.00. Since the possibility values are so high, in this race Horse 3 would be the optimal choice.

FUZZY SETS IN ACQUISITION

The capability of fuzzy set theory to handle vague and inexact data can be directly applied to the defense departments acquisition process. The effort involved in this process can be modeled as an input, process, and output. The system acquired represents the output. The input is a stated need or other appropriate constraint.

The process includes the managing of technical activities while maintaining a balance among cost, system effectiveness, and schedule.

Vague requirements are common, especially during the initial phases of any acquisition. The process itself consists of inexact schedules, funding, decisions, system requirements and system capabilities. Evaluation of the end product can also lead to "fuzzy" determinations. By rigorously applying the mathematical rules of fuzzy logic, decisions and risks can be evaluated from a common base. This enables the acquisition project manager to better maintain the all important cost, system effectiveness, and schedule balance.

The similarities of fuzzy logic to probability and statistical analysis are obvious. This theory, however, is different in that it handles possibilities vice probabilities. Many risk and management decisions can and should be decided using classical probability methodologies, statistical analysis or utility theory. Fuzzy logic cannot replace these tools, it only represents an additional aid in acquisition management.

APPLICATION 1: FUZZY DECISION MAKING

Decisions involving schedule and performance trade-offs are common in the acquisition world. Consider the following dilemma.

As acquisition manager for the new F-30 aircraft you must decide which of two engines to commit to for full scale development. Aircraft requirements and engine performance are summarized in the following table.

	ENGINE 1	ENGINE 2
THRUST	120,000#	125,000
WEIGHT	1000#	900#
COST	$975,000	$975,000

Both engines meet performance and cost requirements. Your job is to determine which engine to buy.

This problem can be simply solved by using utility theory. If each attribute of thrust, weight and cost are weighed equally, and a straight line function is used in the analysis, the utility values would be:

UTILITY VALUES

	ENGINE 1	ENGINE 2
THRUST	120	125
WEIGHT	16	25
COST	7.5	7.5
TOTAL	143.5	157.5

Since Engine 1 provides for the most utility, that would be the obvious choice. Now how would this decision fare if the following information was known.

" Prott Technologies, the makers of Engine 2 has held the contract for F-29 engines for the last 5 years. Unfortunately, management and the unions have not gotten along well, leading to delivery schedule slippages. Major Dynamics, on the other hand, is owned by the employees and are known throughout the industry for their on time delivery record. The acquisition schedule for the F-30 is tight so any schedule slippage increase system cost dramatically. Each week of delay will add $50,000 to Demonstration / Validation cost due to storage problems. Consequently, the delivery performance figures prominently in your decision. Your research has come up with the following figures:

SCHEDULED DELIVERIES

	Prott Tech.	Major Dynamics
On Time	75%	95%
1 week late	15%	4.5%
2 weeks late	10%	.5%

With this information a probability methodology called a Decision Tree could be very helpful. By applying this new information, expected value of each engine can be calculated.

REVISED UTILITY VALUES

	ENGINE 1	ENGINE 2
THRUST	120	125
WEIGHT	16	25
COST	6.7	2.3
TOTAL	142.7	152.3

Frighten by how much labor relations affected Prott's delivery performance you decide to delve a little deeper into their product performance. Unfortunately company security and proprietary rights prevent you from getting any specific figures on the product performance of either company you did, however, get some information.

In comparison to other companies in the industry, Prott's engines normally produce a little less than their rated values. Their engines tend to be a little heavier than contracted for also, leading to somewhat reduced performance in aircraft. On the other hand. Major Dynamics always contract for the minimum they expect to produce. Their engines invariably produce more thrust and weight less than contracted for. This obviously leads to improved performance for their aircraft. Both companies are average in projecting final cost.

Fuzzy decision theory can aid in quantifying this nebulous information. First the utility values for each engine are "fuzzified."

FUZZIFIED UTILITY VALUES

	ENGINE 1	ENGINE 2
THRUST	AT LEAST 120	AT MOST 125
WEIGHT	AT LEAST 16	AT MOST 25
COST	ABOUT 6.7	ABOUT 2.3
TOTAL	AT LEAST 142.7	AT MOST 152.3

With the use of a table, engine "at least" and "at most" membership values for each possible utility value are compiled. By completing a max/min operation on the fuzzy sets, final membership values for each alternative are calculated. In this instance:

Engine 1 = .94
Engine 2 = .50

This indicates that Engine 1 has the best "possibility" of meeting all requirements.

APPLICATION 2: FUZZY GROUP DECISION THEORY [6]

Insights on the dynamics of group decision making can be also gleaned from Fuzzy Group Decision Theory. In a week the Defense Planning and Resource Board will consider funding for the following projects:

(a) Super AAM
(b) SDI Phase 2
(c) Reactive Armor Tank
(d) Advanced Non-Acoustic ASW

As usual defense dollars are short and only two of the four projects being considered will continue being funded. The F-30's weapon system has been designed with the Super AAM in mind. If the missile system is cut, The F-30 may be next. Of the 10 members on the board, only the Chairman, Joint Chiefs of Staff and the Secretary of the Air Force rank the Super AAM number on their list of priorities. The members and their ranking are as follows.

Member	Rankings
Dep Sec Def	b,a,d,c
CJCS	a,d,c,b
USD(A)	b,d,c,a
Sec Nav	d,a,b,c
Sec Army	c,b,a,d
Sec Air Force	a,b,c,d
USD(P)	b,d,a,c
ASD(PA&E)	d,a,b,c
DOD Comptroller	c,a,d,b
OMB Representative	c,a,d,b

After constructing the fuzzy social preference matrix, agreement level sets and corresponding relation matrices are developed. For example the 60% relation matrix is:

$$R_{\alpha=0.6} = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Which gives a agreement preference ordering of:

(a), (b), (d), (c)

This agreement preference indicates that the Super AAM has a better that average chance of surviving the funding battle. Proponents of the Reactive Armor Tank, however, need to start pounding the Pentagon halls. The battle for the bucks will be between ASW and SDI.

FUZZY LINEAR PROGRAMMING [7]

Fuzzy set theory can also be applied to linear programming problems.

" In following the Test and Evaluation Master Plan, you have to complete tests on the aircraft engine's turbine, oil pump, and fuel boost pump. You plan on using contractor facilities, a government test stand, and an independent lab to conduct these tests. Being the end of the Fiscal Year your counting every penny. The test time required and cost for each facility are summarized below.

	GOV'T	CONT.	LAB
Cost/hr	3	5	4
TIME REQ'D FOR TEST (hrs)			
ITEM			
Turbine	3	1	2
Oil Pump	2	1	1.5
Boost Pump	1.5	1	.9
Time Avail	10	10	10

You need to test at least 3 turbines, 6 oil pumps and 12 fuel boost pumps. As always you must minimize cost.

This is a straight forward linear programming problem. The cost objective function is minimize subject to the maximum hours allowed and minimum number of units to test constraints. The results show that it will cost a minimum of $82.86 to complete the test. This minimum cost would only be seen if you could dictate the number of hours used by each facility to four significant digits. Of course this is impossible, but by fuzzifying the problem the most probable cost can be calculated.

First the original linear program is run, but this time maximizing the objective function. This interval sets the "universe of discourse" of cost. The constraints arealso fuzzified according to your desires. For instance you can formulate an ability to exceed the government facility time constraints by up to two hours. From this the equivalent non-fuzzy problem is then written and solved. For this problem the most probable cost comes to $98.32. Being a prudent project manager you aim at the $82 figure but plan on a 18.6% cost overrun.

CONCLUSION

Fuzzy logic and fuzzy set theory provides us with another tool for dealing with an inexact world. Unfortun- ately its threatening notations prevent the average individual from exploring the many "fuzzy" possibilities. I hope this paper peaks your interest enough to take the plunge and join the world of fuzzy numbers.

NOTES

1. Johnson R.C., "That Fuzzy Feeling," Datamation July 15, 1989, pg. 35

2. James Kaminsky, "Technology on Display," Via à Vis January 1991, pg 32

3. IBID

4. Ramesh Jain, "Decision Making in the Presence of Fuzzy Variables'" IEEE Transactions on Systems, Man, and Cybernetics, October 1976, pg. 698-703

5. Odds reflect what those who bet on the race believe the outcome will be.

6. Walter Kickert, "Fuzzy group decision theory," Fuzzy Theories on Decision-making (Martinus Nijhoff, Leiden, Netherlands, 1978) pg 48-52

7. Linear program solution computed using Storm, Version 2.0 (Storm Software, Inc, 1989)

SYNERGISTIC ACQUISITION AND DEFENSE MANAGEMENT

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ABSTRACT

Many recent changes have been proposed and many others implemented in attempts to streamline the Department of Defense (DoD) research, development and acquisition functions. Truly efficient, effective, and economical acquisition of new major system technology for the military requires further integration of the Armed Forces within the DoD. The elements of change in the world environment encourage us to adapt to new realities which greatly affect the complex subject of our national defense. Key among these are the changing world political economic, and military environment, the rapid changes in technology, the relative shrinking size of our world, and the increased pressure to reduce the defense budget. These factors demand that we examine afresh our national strategy and how we will effectively organize, manage, and equip our military forces so they will be prepared to successfully confront all future threats to our national security. The conclusion of this appraisal of our defense structure leads to a more unified and integrated defense force.

The baseline for obtaining cost reductions through further integration of our defense forces is much greater integration of our research and development (R&D) and materiel acquisition (MA) processes, which should be guided by unified operations concepts. While some progress has been made toward eliminating duplication of effort, organizational layering, and streamlining our acquisition methods, the time has come to consolidate all major R&D and materiel acquisition directly under the supervision and control of the Secretary of Defense. Under this concept, all research laboratories, and major systems development and acquisition would be centralized under OSD. Each service would concentrate on establishing the requirements for their equipment and materiel, managing non-major systems and materiel development, conducting operational testing of new acquisitions, maintaining readiness, and conducting training.

This paper examines two alternative options. Alternative A deals primarily with further consolidation of research and development and materiel acquisition functions directly under OSD. Alternative B addresses greater integration of the services through the Specified (Functional) and Unified commands. Greater integration of our armed forces and the establishment of greater unity for the acquisition of materiel within DoD would help to eliminate redundancy; provide for reductions in research and development and materiel acquisition costs; unify major R&D and MA efforts in support of a national strategy; improve decision making; and permit the presentation of a more unified defense program to the President and the US Congress.

INTRODUCTION

"We're entering a new era: The defense strategy and military structure needed to ensure peace can and must be different...What we need are not merely reductions, but restructuring...America must possess forces able to respond to threats in whatever corner of the globe they may occur...To cope with the full range of challenges that we may have to confront, we must focus on readiness and on rapid response. And to prepare to meet the challenges we may face in the future, we must focus on research--an active and inventive program of defense R&D."

President George Bush
Aspen Institute
August 2, 1990[1]

President Bush articulated his vision of a defense strategy on 2 August 1990 (the day Iraq invaded Kuwait) at the Aspen Institute in Colorado. "He [began] by acknowledging that the world remains a dangerous place, with serious threats to US interests wholly unrelated to the former US - Soviet relationship. He [said] that threats can arise suddenly, unpredictably, and from unexpected quarters. US interests must be protected by capabilities that exist and are ready to act without delay. He foresees the requirement to respond to "regional contingencies" as more likely than global conflict. [Forces] must be well-trained, ready, and be deployable quickly to points where they are needed. President Bush calls for an active and inventive program of defense research and development, and for air and sea-lift capacities to be improved. He contends [that] what we need at this juncture is a restructuring of our forces."[2]

BACKGROUND

Some of the strengths of the United States and our system of government are flexibility, ability to adapt, and to change as the situation changes. Has this always been easy for us? Of course not. We have many examples that illustrate our blindness, our stubbornness, and our inertia to make necessary changes. Even with our faults, however, we have managed to overcome significant obstacles, to meet challenges, and not just survive, but move on toward success and progress.

One reason our country has succeeded is because we have been able to marshal our military strength when required. However, in most cases, we have found ourselves in a reactive rather than a proactive mode, not always exercising the greatest possible efficiencies and foresight. Sometimes maintaining even a modicum of military strength for national defense has been a significant struggle.

In assessing our national defense, it is usually appropriate to look at the purpose of our armed forces. It is purpose or reason for being and required functions that drive organizational structure and organizational capabilities. The purpose of our armed forces is to provide for National Defense.

While keeping the purpose and required functions, in mind as we look at possible organizational realignments, there are certain current key factors that should influence our thinking and the decisions we will make. They are relatively obvious, but will be stated below to establish a baseline for a common reference.

- <u>The changing world political, economic, and military environment</u>:

The recent drastic changes in the USSR and Eastern Europe have been astounding and were not predicted by most Westerners and consequently the perceived military threat to the United States has taken some dramatic turns. The possibility of a major East-West confrontation has eased, but the potential for armed conflict particularly in Southwest Asia has continued to grow. International alliances demonstrate volatile characteristics which increase the uncertainly of long-term labeling of friends or foes. The United States must not shed its mantle as a superpower and the responsibilities that accompany that status. The US perspective is and must remain a global one. Our challenge is to be prepared to meet a broad spectrum of contingency conflicts from the low intensity realm of terrorism, counter-insurgency, and drug-trafficking through high-intensity warfare involving large scale conventional or nuclear forces.

- <u>The rapid changes in science and technology</u>:

Rapid advances in technology are changing every aspect of our lives. Our ability to wage and win war places the soldier, the inventor, the engineer, and the scientist on the same team. Success in economic and military competition is now vastly influenced by one's ability to maintain the technological edge. The exponential advances in science and technology place the sluggish achiever at risk to those who maximize their achievements through the best research, leadership, and management, and timely application of resources. It is fair to say that our ability to fully exploit the latest technology and put new weapons systems in the hands of the users has not kept pace with advances in technology. It takes far too long to move new systems through our acquisition management process. Streamlining the acquisition process must continue to be a major goal.

- <u>The relative shrinking size of our world</u>:

Oceans, seas, mountains, and rivers are no longer the defensive barriers they used to be. The changes in communications and transportation have literally turned the world into a neighborhood. We can instantly know what has happened in the furthest reaches of our globe and we can extend our military might into any area within a matter of minutes, hours or a few days. The AT&T commercial which invites us to "reach out and touch someone" can now be accomplished very quickly by sound, sight, or actual physical contact. The physical barriers of yesteryear are no longer the hindrance or a help that they once were. We no longer have the choice of living independently. We are indeed neighbors with all nations, whether we like it or not.

- <u>Limited national resources</u>:

When all factors are considered, the major limiting factor is resources. There are never enough funds to do everything desired for defense even in the best of times. The easing of East-West tensions brought an immediate cry for a "Peace Dividend." We are again faced with reduced spending for defense. The size of our military forces can expand and contract to meet changes in defense requirements, but the least flexible sector of our defense establishment lies within the research, and development community. Manufacturing and production can be adjusted to a degree, but developing the technology for systems to go into production is a long term investment. As budgets shrink, the challenge will be to keep R and D budgets at reasonable levels.

These realities should also drive us at this particular time to re-examine, reassess, and reorient our process for formulating our defense structure and acquiring and maintaining the technology required to defeat any possible threat to our national security.

Organizational purpose and functions and the factors addressed above play significant roles in our future organizational decisions, but it is important to distill truths from recent military history to determine those factors that lead to success, and assess their impact on optimizing our defense structure. Among analyses which have recently been conducted, the three volume study entitled "The Lessons of Modern War" by Anthony H. Cordesman and Abraham R. Wagner identifies several factors that are worthy of note:

"First, in each conflict, it is the side with the best-trained and best-led soldiers that can react to the stress of the final situation of modern war and go on to victory. Numbers do not really count for that much against skill and professionalism.

Second, (a lesson that apparently needs relearning on a daily basis), combined arms forces consistently achieve their goals faster with fewer casualties than forces that cannot coordinate their arms.

Third, military forces that practice and refine their command, control, communications and intelligence (C^3I) outperform forces that do not.

Fourth, it is not technology that gives a military force the edge, but technology which has been absorbed, internalized and can be sustained (repaired and modified) that counts, especially in the third world.

Last, a military free from the blinders of personality, politics or religion (as is especially not true in the case in Iran, Iraq, and Syria) that can objectively and truthfully report its own battlefield performance then analyze that performance and learn from it, has a decided advantage over the long run."[3]

Analysis of the initial U.S. military performance in operation "Desert Storm" indicates that our forces achieved reasonably high ratings in each of the five areas mentioned above. However, it must be recognized that there are other potential adversaries in the world arena that may not be limited in their military capabilities to the extent that Iraq may be. We must continue to re-examine our organization, procedures, and capabilities using historical examples to make the improvements necessary to allow us to successfully combat any potential threat. The second and third lessons above are closely linked to that principle of war called "unity of command." We have not achieved the level of combined arms and joint service training and operations desired.

We have done a fairly good job at developing, assimilating, and utilizing new technologies, but the real world factors and lessons above lead to a conclusion that additional improvements are needed. An assessment considering all elements in the above discussion, indicates the following deficiencies that should be corrected.

<u>Lack of Unity:</u>

Much more progress has been made in recent years to unify the DoD, and to present the DoD to the public as a unified establishment. In spite of this when it comes to research, development and acquisition, the

President, the Congress and the American people see the DoD as separate service entities varying for major program budgets, i.e. kill the Navy A-12 program and give some of the funding to Army ASAT and AF ATF programs. They see parochialism, and a lack of overall defense strategy for planning, operations and materiel acquisition. There is too much rubber stamping of service budget requests by OSD and too much of service direct interaction with Congress without OSD involvement or concurrence.

World War II brought a beginning of change to cooperation between the Army and Navy and Marines. Increased team work was required and ad hoc interservice integration was the norm.

After World War II a separate Air Force was established. This was in effect a *move away from unification.* The creation of the Department of Defense was itself a recognition that there is little or no possibility of a single-service war. The establishment of our Unified commands is an acknowledgement of this reality. DoD has been moving slowly in the direction of greater unity of effort and command for some time.

It is vitally important to have organizational unity, but more important than that is the development of a spirit of unity among the services guided by unified joint how-to-fight doctrine. Of increasing necessity is the requirement for officer experience and training in joint assignments. As already stated, sole service combat operations are obsolete. As an officer rises in rank, he/she must become more joint service oriented. Service parochialisms and self-interest must be left behind. This is particularly important at the highest levels within our services.

The lack of rationalization, standardization and interoperability (RSI) among the services also impacts severely on unity. Standardization of C3I protocols was directed by DoD more than 20 years ago, but has not been achieved yet. This lack of standardization not only impacts unity, but drives up the defense costs because of unnecessary duplication and proliferation. We still have a long way to go to achieve the unity of organization, standardization, team spirit, oneness of thought, and cooperation to maximize our force effectiveness.

Bureaucratic Organizational Layering:

Each service has expanded to provide management and span of control for its numerous functions. This has led to bureaucratic organizational layering which slows, stalls, or paralyzes many functions. Timely progress on any project may be inversely proportional to the number of decision making or influencing organizational layers involved in the process. Materiel acquisition processes are examples of bureaucratic layering and how it can eat up valuable time and require the expenditure of additional time and resources. Conversely, lessons learned from "skunk works" operations show how greater efficiencies in time and resources can be achieved by eliminating unneeded organizational layering. Greater organizational streamlining is required if we are to improve and speed up our materiel acquisition processes.

Focused R&D:

Studies are being conducted to examine the possibilities of consolidating and reducing redundancy among DoDs numerous laboratories and research centers. The possibility of excess in-house DoD R&D capacity exists with a concomitant requirement of maintaining funding levels regardless of the quality of results.

Organizations can become self-perpetuating institutions regardless of output and relevance, but require the continuous consumption of limited valuable resources. DoD laboratories and research centers have made extremely valuable contributions. However, we must assure ourselves that we are getting a good return on focused quality research which is integrated in a timely manner into evolving weapons systems. We can do better and the current efforts toward consolidating laboratory functions is praiseworthy.

Focused Materiel Acquisition:

LTC John B. Hunt points out, in his article "Toward a New Defense Establishment" published in the June 1990 Military Review "There has been constant wrangling between the Navy and the Air Force over the relative utilities of land- and sea-based strategic missiles. The Navy argues within itself over the priorities for carriers and amphibious ships. Within the Air Force, there is competition between bombers and missiles and competition between both of them and fighters and airlift aircraft. The Army argues that there should be more tanks and that the Navy should devote larger resources to sealift. The proposed reorganization would not eliminate these disputes altogether, but would rationalizing them..."[4]. This can be accomplished by considering all requirements together from Unified and Functional Command levels and the separate services. A unified DoD perspective is needed to produce the necessary tools/equipment for the accomplishment of our functional missions.

LTC Hunt further states, "Under the present system, the requirements of the CINCs of the Unified and Specified Unified Commands are subject to the [materiel acquisition] processes of the separate departments, each with its own set of priorities. These CINCs must work their way into the separate combat development systems of each service. The result is duplication, confusion, and frustration" and failure to optimize real world materiel requirements. "If CINCs with responsibilities in low-intensity conflict need fixed-wing, short-range transport aircraft, capable of operating out of unimproved airfields, they [currently] must contend with an [acquisition] procurement system that wants to buy supersonic fighters for its own purposes. It is not that departmental concepts are without merit. [they are.] These concepts are made by men and women of good will and intelligence, who have their own visions of the requirements, not by the commanders charged with employing the forces."[5] However, the dominating vote on material requirements and system acquisition should come from the perspectives of the commanders/staffs charged with intergrating and employing all of the services into winning combat teams.

The CINCs of the Functional and Unified Commands should have a stronger voice in determining the type of weapons systems and number required to accomplish their command's missions. For example, "the CINC of Transportation could balance airlift and sealift requirements and not be distracted by competition within his own service between transports and other kinds of aircraft.

transports and other kinds of aircraft. Procurement of tanks, artillery, [and tactical missiles/aircraft] would be determined more rationally if the Secretary of Defense and the Chief of Defense Staff could weigh the relative requirements of strategic and tactical forces more objectively. In the present organization, each military department is cast in the role of advocate for systems that may have no more relevance to the needs of the country than the preservation of individual service prestige and parochial interests."[6]

In the past few years we have seen organizational changes in the materiel acquisitional arena which are in the right direction. However, these changes have not gone quite far enough and additional changes are required. The following recommendations are in keeping with some of those already made. There are some principle needs that are mandated by functional requirements, by the factors of change, by the current military lessons learned and deficiencies previously mentioned. They are:

1. The need for greater integration and coordination of research, development, and acquisition among the services and the need to continue the streamlining of acquisition organizational management, funds, and control, with the goal of producing materiel quicker, and at lower overall cost.

2. The need to save funds through the consolidation of certain research facilities and functions, the elimination of duplication of effort and to reduce unnecessary interservice competition and rivalry for defense dollars and an associated need for enhanced stature and responsibilities of the Secretary of Defense. This implies reduced visibility and contact of the separate services with the Congress.

3. The need for increased day-to-day combined arms, and interservice or joint training, planning, and operations and the need for greater emphasis on the development of joint service doctrine and standardization of equipment, and materiel acquisition processes, and procedures. The probability of a single service engaging in war is very unlikely. The conduct of war today requires that all services adhere to a common understanding of how-to-fight and win, and all services must train and operate together. There should be greater integration of theory and practice. Joint doctrine should guide joint force structure design and operational planning which in turn should lead to better decisions on how forces will be equipped.

To respond to these identified deficiencies and needs, the following generalized organizational solutions are presented.

ALTERNATIVE A
NEW MATERIEL ACQUISITION INITIATIVES

This alternative is designed to reflect today's realties and incorporates lessons learned from recent conflicts.

It recommends the following key changes to the current DoD organizational structure. The current DoD structure is shown in Figure 1, and a revised DoD organizational chart is shown in Figure 2. The revisions are indicated by the organizational boxes with the heavy black borders.

DEPARTMENT OF DEFENSE[7]

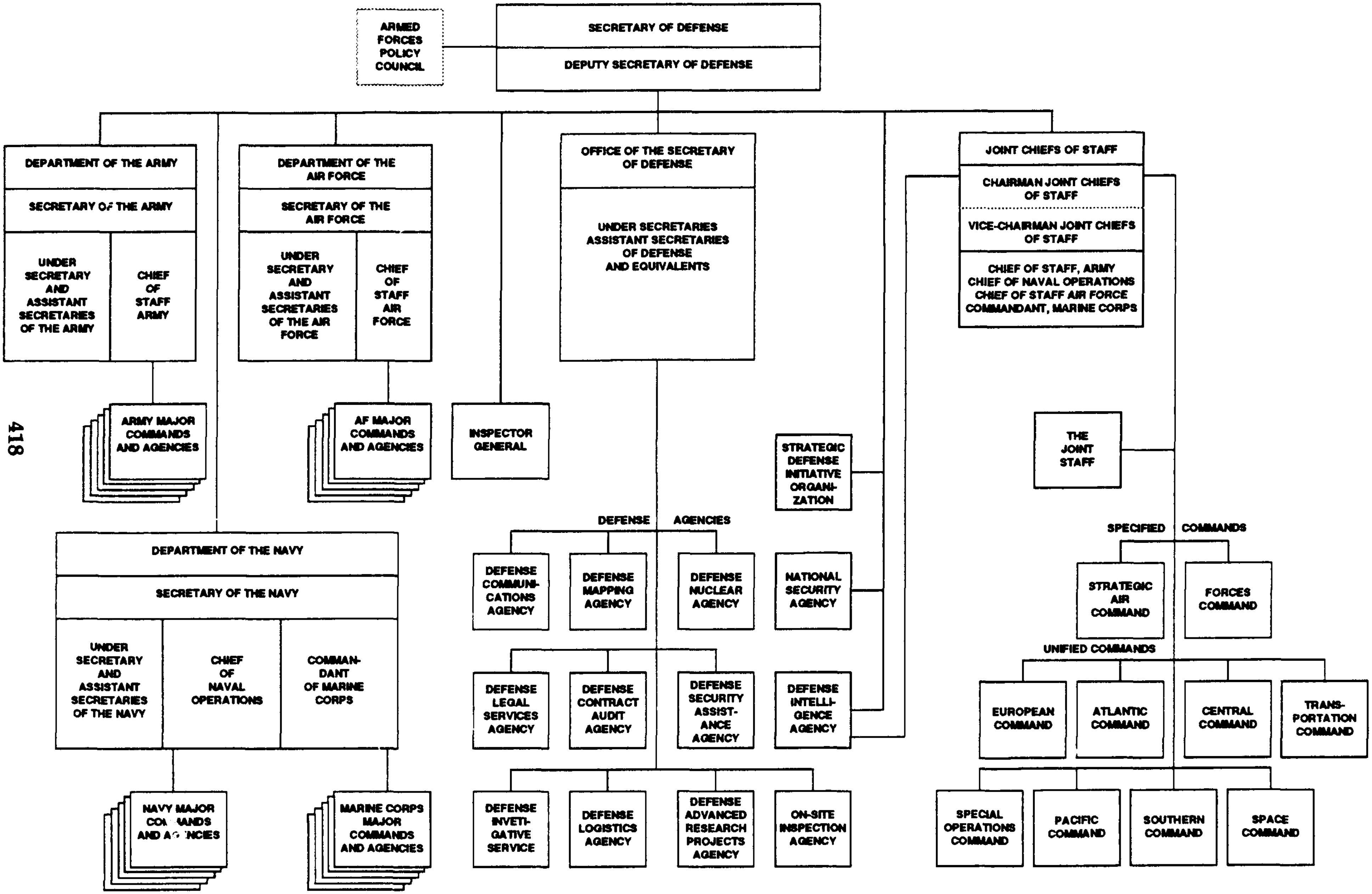

FIGURE 1

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ALTERNATIVE A
DEPARTMENT OF DEFENSE

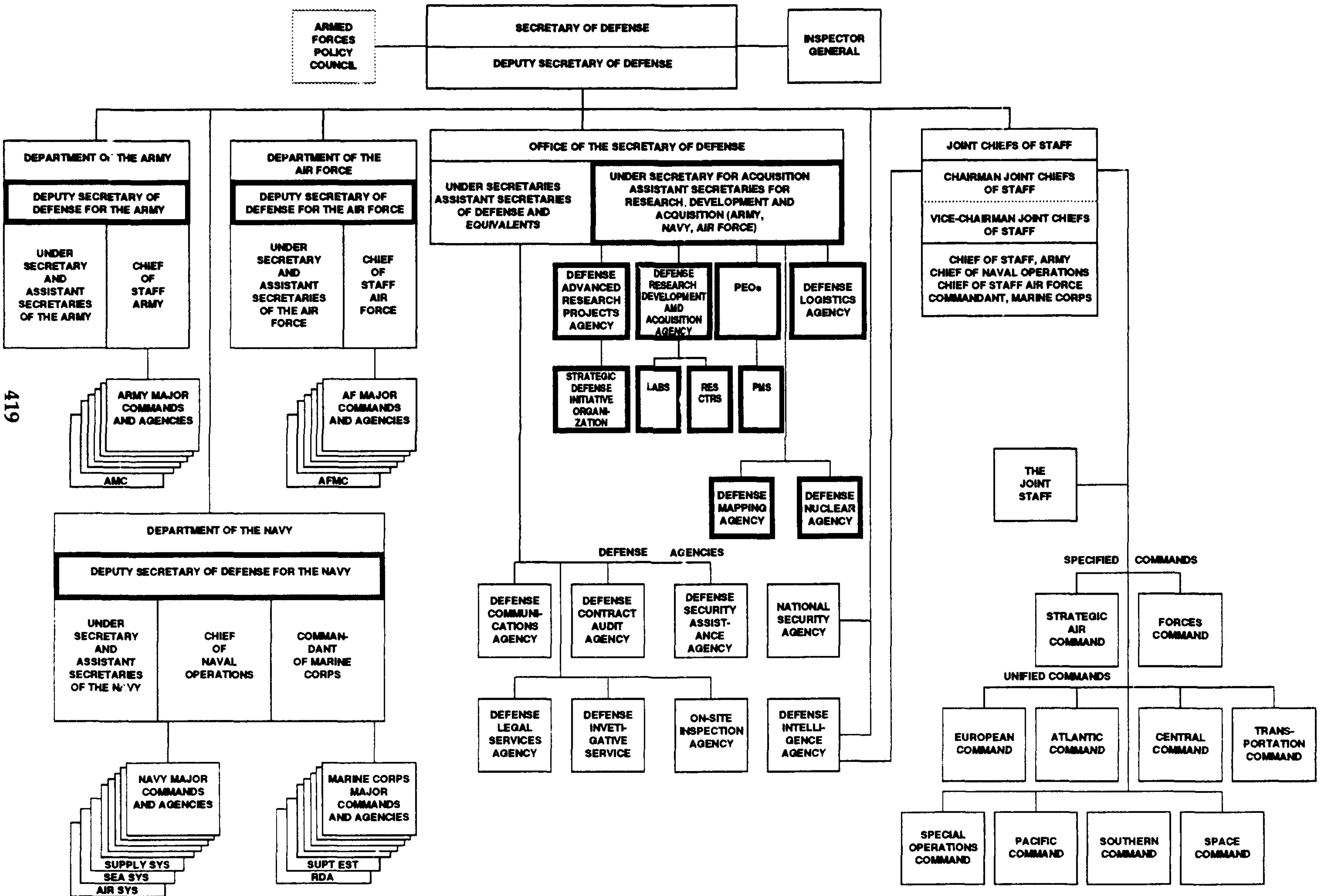

FIGURE 2

2 DOD/C&S 11/90

1. To enhance the position and authority the Secretary of Defense and unity of command within DoD the subordinate relationship of the service secretaries should be clearly shown. One way of showing this is to change the civilian service secretary's titles from Secretary of the Army, or Navy, or Air Force to the Deputy Secretary of Defense for Army; the Deputy Secretary of Defense for Navy; and the Deputy Secretary of Defense for Air Force. These changes should promote greater unity within DoD.

2. The Secretary of Defense, through the Undersecretary of Defense for Acquisition, should assume more direct responsibility for the acquisition of major defense systems (Major defense systems follow the definition in DoD Directive 5000.1.) [8&9]. Each of the service Acquisition Executives, i.e. Assistant Secretary Army (Research Development and Acquisition)/Army Acquisition Executive, would be transferred to work directly for the Undersecretary of Defense for Acquisition. Their titles should be changed to Assistant Secretary for Army Research, Development and Acquisition; Assistant Secretary for Navy Research, Development and Acquisition; and Assistant Secretary for Air Force Research, Development and Acquisition.

They will also retain their titles as Army Acquisition Executive, Navy Acquisition Executive, and Air Force Acquisition Executive. They will oversee all major system acquisitions being developed for their respective services. To emphasize, they will be a part of OSD, not a part of a separate service. The services will no longer be responsible for the acquisition of major systems. Program Executive Officers (PEO) will report directly to these Assistant Secretaries in the case of major system acquisition. The services will continue to select the PEO's and PM's.

3. In the Army, non-major system development and acquisition will be managed by the Army Materiel Command (AMC) with the Commander reporting to the Army Chief of Staff, in the Air Force Non-major system development and acquisition will be managed by the Air Force Materiel Command (AFMC), and in the Navy non major systems will be managed by cognizant systems commands and in the Marine Corps by the Research, Development, and Acquisition Command.

4. A new DoD Agency will be formed called the Defense Research, Development, and Acquisition Agency (DRDAA) headed by the current Defense Director for Research and Engineering (DDR&E). This agency will consist of Army, Navy, and Air Force staff elements and will assume responsibility over all of the service laboratories and research centers. The new Research, Development, and Acquisition Agency will also retain responsibility and manage certain selected potential major systems developments in their early concept stages before they reach Milestone 1. An example of this type of program could be the management of the Joint Tactical Missile Defense (JTMD) Program . This is also an example where decisions should be made early to eliminate possible duplication of effort or consolidate programs attempting to accomplish similar missions. In this case consideration should be given to unifying JTMD, CORPS SAM, Army Tactical Defense missiles, and some parts of the SDI anti-missile defense program.

5. The Defense Advanced Research Projects Agency (DARPA) would operate independently of the new DRDAA and would absorb the Strategic Defense Initiative Organization (SDIO). The main reasons for this change are the reduced need for high visibility and direct supervision of SDIO by the Secretary of Defense, the shrinking SDIO budget and program, the similarities between the two organizations, and the need to reduce the budget and duplication of effort.

6. Other agencies reporting to the Undersecretary of Defense for Acquisition will be the Defense Logistics Agency, the Defense Nuclear Agency, and the Defense Mapping Agency.

7. Materiel requirements for major systems will originate in the Unified and Specified commands and the service components. The Joint Staff will prepare the final Operational Requirement Document (ORD) and will assume responsibility for obtaining materiel requirements concurrence from the required services and commands. Non-major system requirements will continue to be handled within the individual services.

8. Funding for all major systems will be retained and managed at OSD level and major system budget preparation and submission will be managed by the staff supporting the Undersecretary for Acquisition. The new Research, Development, and Defense Acquisition Agency would directly control the funding of the technology base to include basic and advanced research, except for the DARPA budget. All service research, development, and acquisition budget requests, 6.1, 6.2, 6.3, and 6.4 funds would be reviewed and approved by USD(A) prior to being submitted to the Secretary of Defense.

9. No significant changes are proposed for the Defense Logistics Agency (DLA) and service logistics functions. However, consolidation of service logistical functions and procurement should be a continuous effort. Production and deployment management following Milestone III for major systems and budgeting of 6.4, procurement and maintenance funds would be under the direct supervision of the Defense Logistics Agency (DLA). DLA organizational staff elements would be expanded by the assignment of additional personnel from each service to deal with materiel and systems related specifically to their particular service. These DLA service oriented staff elements would interface with the various service log commands.

10. The Program Executive Officers (PEO) who serve as the interface with the program managers of the major programs would report to the Acquisition Executives for Army, Navy and Air Force in the Department of Defense. These Acquisition Executives would be assisted by the staff elements supporting the USD(A). These organizational changes would provide the Under Secretary of Defense, Acquisition, better technical and fiscal control of the major materiel programs, affording him the opportunity to bring them in line with the national security objectives and budget requirements. The overall acquisition function could be made more effective and efficient by providing the Under Secretary of Defense, Acquisition, (USD(A)) more authority and assistance through the organization changes and budget controls presented here.

These changes move in a positive direction towards satisfying the deficiencies and the needs discussed previously. This alternative takes a major step forward, primarily in the system acquisition arena, but Alternative B goes even further toward providing an integrated, cohesive military force.

ALTERNATIVE B
THE NEW DEFENSE FORCE

Alternative B presents some additional changes to the US defense organizational structure and incorporates the changes suggested in Alternative A. The additional ideas in Alternative B do not depend upon the adoption of Alternative A, but are considered complimentary.

Alternative B reorganizes and redesignates the Specified Commands along functional mission concepts. There are no substantive additional changes in the area of research development and acquisition from those presented in Alternative A. However, the functionally and geographically oriented commands will have a much greater influence in the establishment of system and materiel requirements. The thrust of this alternative is greater integration of the services to produce a more cohesive, unified fighting force. As previously stated, we believe that forces that operate together on a day-to-day basis during peacetime, and train together regularly under joint command and staff conditions will have greater chances for success on the battlefield. Potential interservice problems in understanding other service specific SOP, tactical concepts, communications, logistics, etc. can be ironed out before a war starts. Further, the design, development, and acquisition of weapon systems, communications equipment, supporting material, and common supplies can be more efficiently and effectively managed through greater service integration. This alternative is designed to do that.

1. We begin the suggested changes in Alternative B by changing the word "joint" to "defense." The Joint Chiefs of Staff should be changed to the Defense Chiefs of Staff, etc. The Joint Staff should be renamed the Defense Staff. The basic thought for this change, though a subtle one, is that we should not have a "joint" staff composed of separate services, but one unified defense staff. The directive authority of the Chairman of the Defense Chiefs of Staff should be enhanced and the Defense Staff should become more involved in strategic planning, developing joint doctrine, processing materiel requirements for major systems, establishing service organizational force structures and force levels, and serving as the primary interface with the service staffs and the Specified (Functional) and Unified Command Staffs. Recall also that in Alternative A, we redesignated the Secretaries of Army, Navy and Air Force as the Deputy Secretaries of Defense for Army; Navy; and Air Force. This change is also included in this alternative. The additional organizational changes presented in Alternative B are shown in Figure 3 and are contained on the right one-third of the chart under Defense Chiefs of Staffs.

2. The term "Specified Command" would be changed to "Functional Command." The term "Unified Command" would be retained. There are no changes to the organization, missions, and functions of the Unified Commands. The Unified Commands

ALTERNATIVE B
DEPARTMENT OF DEFENSE

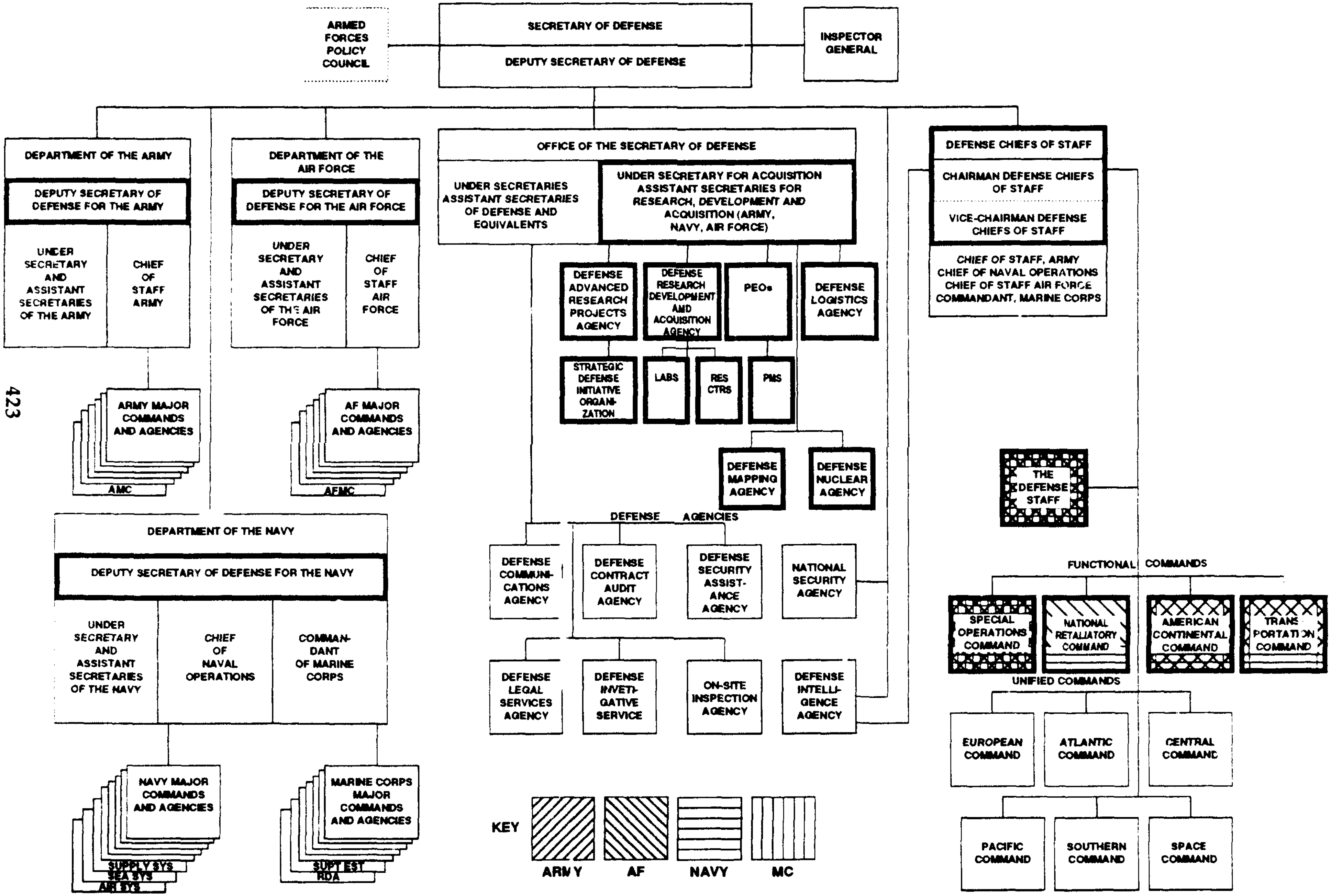

FIGURE 3

3 DOD/CAS 11/90

will retain their geographical orientation including the airspace above their regions. They will be the European Command, the Atlantic Command, the Central Command, the Pacific Command, the Southern Command, and the Space Command. In fact, all Functional and Unified commands are integrated service commands consisting of elements of two or more services.

3. The Functional Commands will be the Transportation Command, the National Retaliatory Command vice Strategic Air Command, the American Continental (Land/Sea/Air) Command vice Forces Command, and the Special Operations Command. There are no changes being proposed for the Transportation Command and the Special Operations Command, but they would be redesignated as Functional Commands. The strategic deterrent and retaliatory mission would be under a single Commander-in-Chief (CINC) of the National Retaliatory Command (NRC). The NRC will control long range bombers, Air Force cruise missiles and land based Intercontinental Ballistic Missiles (ICBM), and the Navy Submarine Launched Ballistic Missiles (SLBM).

4. The American Continental Command (ACC) is primarily an Army command but contains elements of all of the other services. It will have responsibility for the continental defense of the United States and coastal areas. The ACC and the separate services will be responsible for providing combat ready forces to the various Unified Commands in support of contingency operations.

The American Continental Command will have operational control over many continentally based service units and actually has missions that could identify it as either a Unified or a Functional command. It is geographically oriented on the continental United States, but at the same time performs significant functional and combat readiness responsibilities related to the overall US defense effort. For the sake of emphasizing its functional missions, the American Continental Command is placed in the Functional Command category.

6. The CINCs of the Functional and Unified Commands would continue to be responsible to the Secretary of Defense through the Chairman and Vice Chairmen of the Defense Chiefs of Staff.

7. The roles of the individual services will be diminished to some degree as the Defense Staff and Defense Chiefs of Staff and Functional and Unified commands are strengthened. The Departments of the Army, Navy, and Air Force are still our defense building blocks. but they do not supervise combat operations. Their primary mission is to organize, train, and equip forces to be supplied to the current Specified and Unified Commands who are the real world warfighters. As in Alternative A, major defense system materiel acquisition will be managed by OSD. All other materiel acquisitions required to equip, maintain and sustain the forces will remain the responsibility of the services.

As it can be seen in this alternative, we are downplaying the separateness and power of the services, enhancing the authority and responsibility of the Functional and Unified Commands, OSD and the Defense Staff, and promoting integration and unity. There are three principles behind the changes proposed in Alternative B They are:

- Unity of purpose!
- Unity of purpose and function!
- Unity of purpose, function, and command!

CONCLUSION

Someone has said that the only thing that is constant is change. The wise and prudent study change and adapt to it. Our armed services have evolved into an extremely capable fighting force, but there still remain a number of ways we can continue to improve. The preceding alternatives present some ways that contribute to increased efficiencies and effectiveness. The rationale supporting the need for further change was discussed.

We are moving in the right direction and we should continue to pursue appropriate changes within our defense organization with even greater deliberation and determination. We should continue to be guided by the objectives of reduced cost, reduced development time, greater interservice cohesion and unity, and the elimination of duplication of effort and waste while taking full advantage of new and emerging technologies.

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CONTRACTING DIRECTION FOR THE 1990's: SELECTIVE-CHOICE

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ABSTRACT

This issue paper addresses the feasibility of applying "selective-choice" contracting techniques used by the private sector in the national, as well as the international contracting arena, to government or quasi-government contracting practices in the 1990's. The methodology used to implement selective choice is not new. It is just the best overall value determined by use of negotiated contracting procedures (In layman's terms - prequalification in combination with fixed price cost evaluation).

Although Dr. W. Edward Deming's Total Quality Management (TQM) concepts have not been accepted by a majority of U.S. corporations afflicted by organizational cultural resistance - a few corporations have successfully overcome this affliction by making a total commitment to selective choice based on quality related prequalification (prequal) criteria.

This study was originally based on the only known statistics published by the Xerox Corporation. By restricting the number of sources through the use of selective choice techniques, Xerox was able to achieve significant cost reductions as a by-product of a commitment made to a continuous improvement in quality-related criteria. On one hand, close ties with a few sources have often been misinterpreted by the press as sweetheart deals. On the other hand, many contractors often misinterpret "prequal" to be a difference between "qualified" versus "not qualified" rather than the true difference of "qualified" versus "well-qualified". Reduced vendor sources are a natural result of this type of "selective process".

This occurs not because of lack of competition, but because only a few firms have a better track record than others in the practice of actually maintaining and improving the quality of the goods or services provided to their customer. Standards of adequate competition remain; any firm <u>may</u> compete, as long as it is willing to demonstrate a commitment to continuous quality improvement. The private sector has found that by continual improvement in the prequal standard, firms march to the beat of quality service with subsequent cost savings.

The principal conclusion is that agencies in the government or quasi-government contracting arena can realize the same cost savings by the proper application of negotiated contracting procedures. At the present time, only the U.S. Postal Service has made the bold move to adopt a new procurement policy based on achieving the best overall value using negotiated contracting procedures.

INTRODUCTION

BACKGROUND

The current contracting direction takes its theme from thoughts by the poet T.S. Eliot:

> "Where can the world resound;
> where can the word be found;
> not here; there's not enough
> silence."

Many people in the marketplace continue to blow bubbles of noise in the air; not silence.

Noise from political-economical factions on emotional issues, not factual issues, have overburdened agencies to manage contract operations by crisis techniques using old yardsticks. The current contracting thrust in the commercial sector that has produced continuous quality improvement from firms for goods or services is based on making informed choices. They spend more time upfront in evaluating the past performance track record of firms in their contractor base that actually practice this improvement process. The contracting direction for the 1990's is headed for use of new yardsticks - "the benchmark."

Everyone in the government or quasi-government contracting arena would like to see improvements in cost control and cost reduction without hindering service. How can contracting departments in these agencies contribute to this objective? How can we continually adapt to increased workloads while operating within tighter project budgets? While facing these challenges, how can we offer better service within current staffing levels? A few corporations in the private sector are doing just that. Can the procedures they used, with subsequent cost saving, be applied to the goverment or the quasi-government method of doing business by contract? Yes they can. How are these companies doing it? By selective choice.

If their method was translated into our contracting language, the procedure would be called competitive negotiating procedures. The method would be called competitive sourcing by some competitive benchmarking by others. The option for this procurement policy at many agencies is already in place.

Agencies should set their course to fully use the power of selective choice in conjunction with benchmarking techniques to achieve the cost savings currently realized by those in the commercial sector.

The bookstores are filled with books on Professionalism - Quality - Responsiveness techniques practiced by the private sector in their dealings with their sophisticated customer. These books report the success of a few corporations that have excelled in providing quality service, at substantially reduced costs. In Search of Excellence, Renewal Factor, One Minute Manager, etc. cite numerous examples of cost savings by certain companies in their operational expenditures, particularly by their buying departments (procurement and supply, facilities, real estate etc.). The recent book Japanese Contruction - an American Perspective stated that "the Postal Service has lifted a page out of the Japanese government manuals and instituted a system of prequalifying bidders, which in their opinion will result in a better end product." A terrific compliment. Unfortunately, prequalification is still not a word in the Federal Acquisition Regulation (FAR) lexicon, even though the Competition in Contracting Act (CICA) switched the emphasis from formal advertising (sealed bidding) to competitive negotiation as the preferred method of contracting.

Of course there are still those inside and outside the government arena that take the stance that most buys have defined scope and therefore price alone should determine the winner. The obvious flaw in this stance is the presumption that the low price is the best overall cost.

Malcolm Baldrige Award winner data (validated by the Department of Commerce) overwhelmingly supports the other argument: that the best overall value is achieved by analysis of total cost, not price. A premise, voiced by Mr. John J. Hudiburg,[1] former Chairman of Florida Power & Light Company (FPL). In his words many companies are giving lip service to quality, but are failing because they are resisting a new management paradigm.

I know there has been a lot of Malcolm Baldrige criticism lately about how only the big firms have been able to satisfy the 'stiff' competition requirements after they spent a lot of money on consultants and training. Its true, companies like Xerox and Motorola had to spend tons of money on the real basic training in statistical process control and...remedial education for both white and blue collar workers. Remedial education...what's that? It's exactly what you think it is...reading, 'riting and 'rithematic. "Six hundred thousand high school graduates can barely read their diplomas". I didn't say that. Lee Iacocca, Chrysler's chairman, said that at the National Education Association meeting two years ago. Some of these same high school graduates probably went into the contractor workforce or went on to college before filtering into the contractor base.

"Our education system is turning out citizens too illiterate to meaningfully participate in the political process". I didn't say that. Walter Cronkite said that at the Harvard University Kennedy Foundation School of Government. Does too illiterate to meaningfully participate in the political process equate to being literate "enough" to contribute to an American business TQM improvement process?

Who are these Malcolm Baldrige critics trying to kid? The big companies had to make some tough choices in a dwindling market to divert profit dollars from shareholders to training dollars to train their employees. True, the small firm is not in a position to do this. The choice is either to better screen your new hires, by reading "Swim With the Sharks" or go out of business after showing your employees the HBO movie "Roger & Me". Follow the classic notion approach to cut costs by dowmsizing. In the words of Motorola Vice President, Phil Kelly -- follow the notion of a flea-training mentality.

How often does a contract go well? How often are contracts plagued by problems attributed to inefficient management practices by that low offeror (that had that definitive scope everyone bases their laurels on)? Those in our business know the answer well - a history of broken hearts. It's somewhat similar to the situation the Office of Personnel Management (OPM) currently finds itself in. OPM extolls the virtues of Total Quality Management (TQM). At the same time OPM is promoting individual appraisals: which run counter to the TQM principle calling for their removal. Catch 22 seems to be a frequent dilemma in government circles.

In the federal sector, FAR indicates a firm-fixed price contract is suitable for acquiring commercial products or for acquiring other supplies or sources on the basis of reasonably definite functional or detailed specifications when there is "adequate" price competition. Adequate within what context? Competition among firms whose only claim to fame is that they have a business card stating that they are still in business; or competition among firms whose past track record for actual continuous quality improvement indicates competition among their own peer group.

The Contracting Officer will not be paying for the cost[2] of nonconformance with the firm that has a track record of doing the job better the first time and every time. In addition to the data from Malcolm Baldrige award winners, other studies[3,4] complement this data. Studies indicate that time spent by the private owner before award to determine those firms which are the most qualified ones to compete results in obtaining the best overall value.

METHODOLOGY

The objective of my analysis was to take a look at the data from firms that were successful in achieving quality improvements in their contractual operations; particularly Malcolm Baldrige Award winners. However, of all the corporations in the United States, only a few firms are pursuing such selection methods - as is evidenced by the small number of Malcolm Baldrige contenders that ever make it to the interview stage. In 1989 for instance, the management in 167,000 firms thought their firm was Spartacus and applied for an application. Only a very small number made it through the criteria evaluation stage.

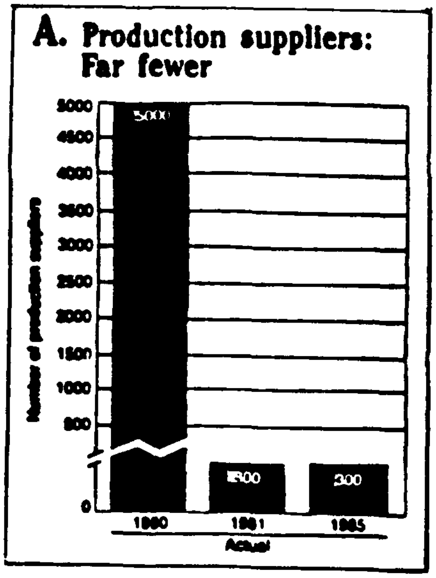
It is significant to note that the Malcolm Baldrige Award criteria is based on Public Law 100-107. It represents the will of our citizens and Congress to expect firms to establish higher benchmark standards regardless on whether that firm is large or small. The TQM improvement process according to Mr. Hudiburg can achieve spectacular results for any company that defines progress in terms of customers' needs.

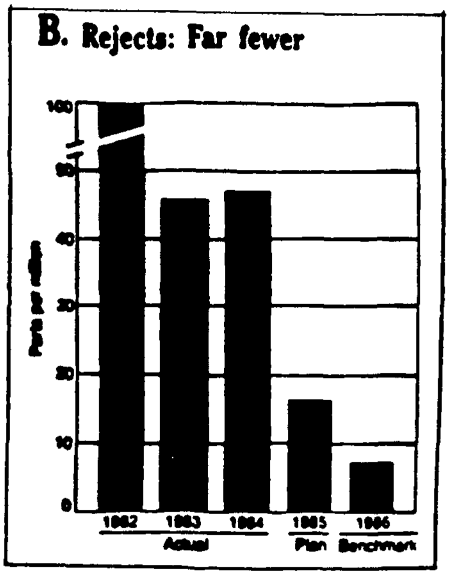
The real competitive advantage lies in being "noticeably better than your competitors."

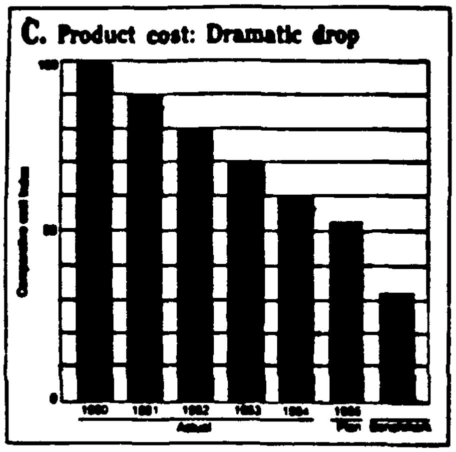
The contractual statistics[5] of Xerox Corporation is repeatedly cited as an example in the statistical literature. In just four years, (using 1980 as a base), Xerox Corporation reduced the costs of what they purchased by 40%. The following figures A thru E show the results from Xerox's supplier/vendor selection procedures. At the same time, Xerox maintained their buying level with much improved quality. Xerox practiced selective choice based on a higher standard, regardless of the dollar value of the purchase.

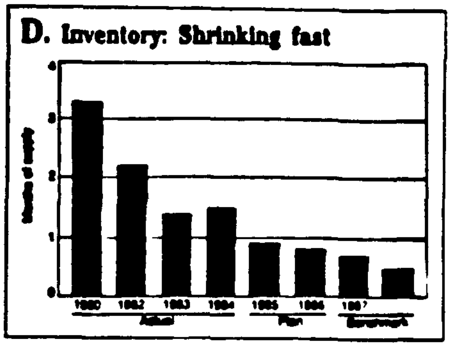
Hewlett Packard and Motorola were two other firms that obtained similar results. How did these companies ACHIEVE such remarkable results? Did someone write a memo and say costs would be reduced effective tomorrow and draw a line through their budget? No, the firms that did that were unsuccessful. So how were superior results achieved?

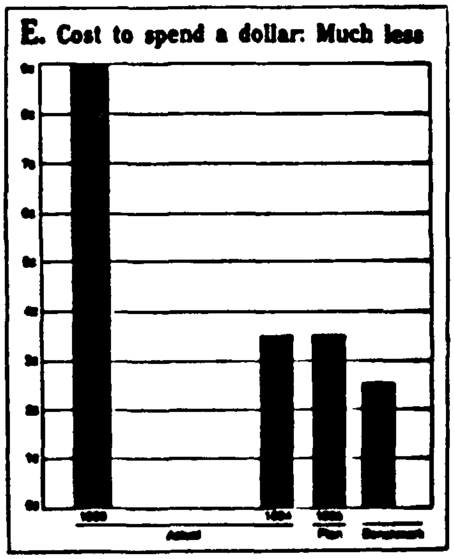
The answer is simple; everyone in the corporation questioned each and EVERY contract transaction as to why they were doing it that way, and what could be done to improve buying quality. The result was cost reductions as a BY-PRODUCT of establishing a purchasing standard for each and every buying action for all goods and services. Even though most of the attention regarding TQM has been in the private sector manufacturing arena, the improvement process is equally applicable to the other areas: procurement and supply, architect-engineer (A/E), construction, and real estate contract operations, etc.











**THE TRENDS ARE POSITIVE--
AND RELATED**

The results of Xerox's centralized commodity management and supplier training programs, charted here, have all been positive. What's more, they're inter-related in a classic cause-and-effect pattern. To wit:

A: The drastic reduction in the number of production suppliers has been one of the number-one "enablers" for the other programs.

B. The quality improvement is directly related to working with fewer vendors, training them in statistical process control, and giving them an early voice in new product design.

C. Early supplier involvement, as well as volume leverage, has netted cost reductions of close to 10%/year since 1980.

D. Inventories, already down, are expected to shrink even more as just-in-time training for suppliers gets up to full speed.

E. Smaller vendor base and systems efficiencies enable the materials job to be done at lower cost without inhibiting professionalism.

What Government Leaders Say About Total Quality Management

Federal
"Reasserting our leadership position will require a firm commitment to Total Quality Management and the principle of continuous improvement. Quality improvement principles apply to the public sector as well as private enterprise."
President George Bush

State
"The quality approach to management taps Wisconsin's most important resource, its people. Quality management stimulates individuals to strive for the best to take personal pride in the output, and be reinforced in their sense of personal worth. That's what I want for my administration."
Wisconsin Governor Tommy Thompson

Local
"Why do we spend so much time and energy on quality management? Because it is the key to constantly improving the quality and efficiency of service to our customers -- the citizens of Wilmington. That's what good government is all about."
William B. Farris, City Manager, Wilmington, NC

These are the key points that are entirely missed by the press. Newspaper articles report the private sector forging close ties with a few suppliers, A/E's, manufacturers and construction firms to achieve excellence (quality) and the resulting cost savings to the corporation. To the uninformed, these appear to be sweet-heart deals with a stable of suppliers, whereas nothing could be further from the truth.

They leave out the middle step - total commitment to maintaining a high standard achieved by selective use of prequalification techniques and then letting only those firms that actually satisfy the "higher standard" compete on the same basis. The process does not end there. The standard is passed down to the subcontractors of the prime - resulting in the so-called closely knit association referred to in the newspapers as "partnering".

And EVERY YEAR these corporations in the private sector made that standard better - that is, continuously improved the standard based on changing market conditions. The net effect includes substantial cost reductions without any impairment of service to the customer. Potential offerors who want the business to go in their direction from a customer that establishes a higher standard have to continually improve their own standard of quality. Cost reductions are a natural result - the by-product of this effort. Competition marches to the beat of a quality standard set by the customer. Therefore, quality is continually improved to the sustained satisfaction of the customer. This is nothing more than the TQM philosophy appearing in reports published in the private sector by the professional trade journals on an ever increasingly basis.

Body/Text

How does this private sector information apply to agencies in the government or quasi-government arena? Do we, as an agency within this structural bureauacy want to achieve the same quality and cost effective results? Yes we do and we can. How? Don't we have competitve negotiation procedures as an optional tool?

Yes, for it sounds good in theory; but in practice it still may not operate as intended if only lip service is given to the effort.

One reason is that there are still two choices Contracting Officers have to choose from even if they elect to apply negotiating contract procedures. They may choose the winner for the contract based on (1) price alone or (2) technical criteria (prequal) in addition to price.

The first choice is predominately used by a majority of our Contracting Officers since it is less time consuming than choice two, and does not tie up limited personnel resources. It's just another version of the bid system but with a little more flexibility that is permitted by the negotiated contracting rules. Besides, isn't the scope clearly (definitive) defined by the solicitation document? The record speaks for itself doesn't it? Fact or fiction: The majority of all contracts awarded based on price alone start on time and are completed within the timeframe originally stated to the total satisfaction of the value system adhered to by the Contracting Officer.

The second choice is labor intensive and not preferred. People cannot seem to find the time in the beginning to prevent problems, but seem to make the time after contract award to correct problems. In the long run, through, error correction after award costs more in both time and money instead of error prevention before award. The first choice of cost alone is just the "bid system". The postal service is the only agency that discarded the bid system. The U. S. Postal Service[6] moved away from the LOW bidder scenario and subsequent results.

The U. S. Postal Service opted to make the bold move toward making better business judgements by abandoning the bid system in favor of determining the best overall value. Of course they were met with an outcry of concern on the increasing trend toward use of negotiated contracting procedures. In layman's terms the process used by your mother in determining which butcher to buy that USDA grade (solicitation requirement) meat. I hope we can all agree that everyone has a mother.

Numerous attempts[7] have been made to revise the government procurement system. Commission report after commission report make similar improvement recommendations. Actions to implement these recommendations move like a turtle through the government system. The trend is to continue to "study" the same issues like waiting to see if a stone can grow -- lobbying groups do a terrific job of holding back needed improvements: Augustinian Code XXII:[8] If stock market experts (lobby group) were so expert they would be buying stock, not selling advice.

However, the second choice, award based on technical criteria in addition to price, <u>if utilized</u>, results in <u>selective choice</u> of the superior firm. If based on the establishment of the higher quality level (higher benchmark established)[9] - the result is the winner being selected on best overall value. This also offers the best protection from protest action by an unsuccessful offeror, assuming the Contracting Officer thoroughly complies with our fairness requirements i.e., competition based on the competitive benchmark process. The selection based on technical criteria in addition to price is the predominant system the private sector is using to achieve cost reductions.

Not all corporations are using it. At the very lease it is the system employed by the top flight firms like Xerox that have made a TOTAL commitment to improve their buying power. These few corporations are experiencing the fruits of their labor and conviction: improved quality and cost reduction.

TQM PROGRESS

How did the aforementioned companies achieve their success? How can we make it happen? Where does it begin - with management? In reality, the past winners of the Malcolm Baldrige Award, whether they realized it or not, all used variations of Dr. Edward Deming's quality approach. Cost savings in their external contractual operations involved goods and services obtained through use of "selective choice" techniques (prequalification in combination with cost evaluation). Relationships develop when the common bond is continuous quality improvement. The current buzzword is vendor/supplier "partnering". Although the word "partnering" is often perceived negatively in the government contracting arena, it should be seen as an environment in which sources compete based on competitive benchmark techniques.

In the movie, "Cobra", Sylvester Stallone was asked "Do you have an attitude problem?" His reply: "Yeah, but it's just a little one." The problem is that only a few have a true businessman's attitude. This is the biggest obstacle to overcome in attemtping continuous quality imporvement efforts. There are very few firms, utilizing such processes due to this impasse.

We must assess potential Contractor's ability to perform based on careful scouting of their performance record and also a thorough review of their management's commitments to continual quality improvement Lean toward the top contending offerors (the highly qualified ones) that exhibit an unwavering commitment to achieve benchmark status.

The most successful firms in any industry have all relied in some manner on Dr. Deming's management approach - his fourteen points. His approach focused on the continuous improvement process. Two of his key points that can be applied to our arena:

- Point 3 - "Cease dependence on inspection to achieve quality"

In the government or quasi-government arena, we are reluctant to trust the Contractor to perform as promised. Why? Most of us have been disappointed in contractor performance in the past. Our cumbersome solution is to create more contract "boilerplate".

The common misconception is that, by putting more in writing, the sheer weight of the thick contract document will motivate the Contractor to satisfy the government requirements. It only fuels the fire for attorneys on both sides of a battlefield where semantics are argued. (Statistical process control techniques indicate the probability that 50% of the top lawyers graduated in the lower half of their class.) Draw your own conclusions from legal outcomes. Of course, we try to see that the Contractor complies with all our written words (pages and pages of boilerplate), by continuous peering over his shoulders, giving him advice or a punchlist to fix this or that.

The subliminal message we sent is that we will babysit a less than satisfactory contractor and unnecessarily annoy a competent one.

In either scenario, we ultimately increase the cost of doing business with us. Only when we finally begin to select (consistently) the motivated contractor that is competent in actually achieving continuous quality improvement will we eliminate the need for the babysitter.

- Point 4 - "End the practice of awarding business (solely) on the basis of the price tag."

The Construction Industry Institute Publication 10-4 (April 1990) entitled "Total Quality Management: The Competitive Edge," highlights the fact that companies must implement total quality management (TQM) or become non-competitive in the national and international markets within the next five to ten years. Solely relying on the government process used for the determination of responsibility, prior to award, does not identify those firms that operate at a higher standard than their peers. It is only an indicator that the firm remains solvent, but not how well the firm minimizes the cost of non-conformance with requirements cited in the contract.

Our current problems rest with continuing to do business with the Contractors that persist in the practice of inefficient management styles. Occasionally, we are fortunate enough to discover that the low offeror is one notch above the competition. This is the rare exception. A vast majority of the firms depend on our limited resources to get them through the job.

How many firms with a reputation in the commercial market do business with us? Very few. They cannot effectively compete with firms that do not satisfy the higher standard within their professional industry peer group. This process can only be reversed by seeking Spartacus. Although there is only one Spartacus, we should be establishing benchmark standards where prospective offerors compete on the basis of the higher standard, and we must short-list to those firms that are at the head of the pack, not the tail. That is <u>if</u> we are really serious about quality improvements? That we are not swayed by various lobby groups that want you to try meat from a butcher not up to your mother's standards.

A few companies, such as Xerox and Motorola, have clearly shown that cost savings are a by-product of competition that marches to the beat of quality (a higher standard). Instead of leaning toward quick-fixes, we should position ourselves for the long haul by implementation of selective-choice contracting techniques based on the concepts I described. Concepts based on striving toward a total quality benchmark in every endeavor and at every level.

We must be willing to commit ourselves on both institutional and personal levels. A value system based on higher standards.

CONCLUSION

Xerox is but one example of those superior organizations that have successfully broken new ground in contracting by achieving quality improvements using selective-choice contractual techniques. Those in the government or quasi-government arena can apply these same selective techniques.

How? Make a committment to use non-traditional approaches based on comparing firms to various benchmarks: a higher standard. This process called competitive benchmarking is not to be confused with the same term associated with first article testing. By application of benchmark techniques Xerox's data validated continuous cost-reductions of 10% per year. Two key elements to Xerox's success: (1) they did not do business with any firm that did not have a reputation for statistical process control for maximum cost effectiveness; (2) they required full cost disclosure from the successful contractors where award is based on best overall value (not necessarily the lower offeror). What is even more startling is that Xerox is applying the same improvement process to the non-production side of the house - the non-supply operation with similar success.

Benchmarking involves targeting prequalification characteristics of potential member firms before you elect to consider them for your work. These include:

- experience & qualifications of personnel
- repeat client reference
- firm's documentation of quality improvement presence with a continuing education program
- strength of a real quality control program (fact or fiction) - figment of imagination or actually doing it
- technical expertise

Total Quality Management (TQM) is achievable within the framework of government contracting. The same techniques used by a few corporations in the manufacturing arena to achieve success are directly applicable to firms in any arena: supply, design, etc.

I believe the impass to date is caused by a prevailing attitude that the problem in the services arena is more complicated than the manufacturing arena.

Our problems are not going to go away unless we take a positive approach that leads to a long-term solution. Businesses and corporations are running out of the precious commodity called time. Problems are outpacing the solutions unless we find a way to catch up fast. Cost containment efforts are a failure. If you try to control one part of the system, you just have cost shifting into another part of the system.

The simple process I've identified is really going back to the real basics that started with Dr. W. Edwards Deming in the early 50's. He patterned his approach after Charlie Chan, who believed that "Truth is like oil; will eventually rise to surface". His approach was driven by customer satisfaction. Operations were continually improved by simple application of cause and effect diagrams (Pareto charts); just real basic statistical fundamentals. Over the years, the approach was refined by many others, including Philip B. Crosby.

He seems to have patterned his approach after Columbo who believed "All you gotta do is figure out why?" One is aware of the successful results of a few corporations only after doing a lot of reading to understand the process. It started with top management making a commitment toward total involvement of people in both internal and external operations.

It is not a process where everyone has something else to do. After the cake comes out of the oven, everyone now wants to have a piece of cake to eat.

The baking of the cake is a painful experience. It involves TOTAL involvement and TOTAL commitment of everyone. All the ingredients have to be right.

The article entitled, "Creating an Empowering Environment for all Employees" (June 1990), by Frederick W. Smith - Chairman and CEO of the Federal Express Corporation, highlighted his views. His firm's philosophy was very simple: The customer comes first.

Everyone in his firm was commited to this philosophy. Net result, in his own words, "Profit is a natural by-product", i.e., when people are given the highest priority, profit is a natural result. When profit comes first and people last - the profit objective can not be guaranteed. Now some may say, "That's a private company, not us. We're different, we're in the government on quasi-government arena. We are not in business to make a profit but to break even." True, but we are in the business to provide service to all of our customers -- on a quality and cost effective basis.

At the same time, we must operate within tight budget restraints. We continue to say we are already doing this but...at the same time, we also say we want to cut down on your costs, as well as provide more and better service.

To continue to operate in the same manner is taking its toll on our employees, and I believe we have reached a saturation point. To continue to do the same things the same way leaves us stuck in a rut. We will remain in a state of paralysis unless we act to correct it. If we don't make measureable improvements happen; if we continue to do things the same way all the time, we will continue to get the same results; not the results obtainable by selective-choice techniques.

The first step in establishing success would involve establishing a benchmark applicable to the specific contract that would be our vision of a higher standard. The higher standard for evaluation of competing firms would be patterned after the eight critical factors identified by the Malcolm Baldrige National Quality Award:

- A plan to keep improving all operations continuously.
- A system for measuring these improvements accurately.
- A strategic plan based on benchmarks that compare the company's performance with both the industry's best and the world's best.
- A close partnership with suppliers and customers that feeds improvements back into the operation.
- A deep understanding of the customers so that their wants can be translated into products.
- A long-lasting relationship with customers, going beyond the delivery of the product to include sales, service, and ease of maintenance.
- A focus on preventing mistakes rather than merely correcting them.
- A commitment to improving quality that runs from the top of the organization to the bottom.

Our current vendor base may not be available to meet our year 2000 requirements unless we take positive action to change the value system of the industry toward the customer (us). Firms are having no problem going out of business even though their industry is currently "not officially" targeted by foreign competition. Based on the Dun & Bradstreet Business Failure Record, most industry failures are running parallel to the failures in the manufacturing sector.

Around one out of every two firms fail in less than five years: a 50% atrrition rate.

Even when a particular industry is officially targeted by foreign competition, like the U. S. Semiconductor Industry, the industry is slow in responding to the known threat. In the 1980's, the United States held better than 80% of the semi-coonductor market. In just ten years, the United States is struggling to maintain under 50% of the market - and still no one in their industry is motivated to yell FIRE! FIRE! FIRE! If one were to extrapolate the data, it would appear the fate of the semi-conductor industry could follow that of the U. S. TV industry by the year 2000. i.e., bound for extinction.

Very little action is being taken by any of our industries to reverse these disasterous trends. Only one TV commercial, by Rockwell International, actually places emphasis on "Education...it's our future."

Firms in our other industries prefer sitting on the bench rather than taking action on the playing field. They smell the smoke but raise no alarm or yell FIRE! They prefer to say "that's a manufacturing industry problem; not ours".

They disregard capabilities of a formidable competitor. Toyota sets customer satisfaction as their number one priority. Globalization is second. Based on Fortune Magazine, Toyota only nets 2.9% from sales in the United States, yet, has only 91,790 employees compared to the 766,000, at GM. Lag in quality in their United States operations is blamed by Toyota production manager on the lag by U. S. suppliers in maintaining quality standards.

He stated, "They aren't up to European standards, much less Japanese." Many shows have appeared on public television and cable focusing on the future world markets. When the man in the street is asked where is competition coming from, the answer "from Germany and Japan". I have yet to hear the United States mentioned in these newcasts from the man in the street.

Our contractor base should be smelling the same smoke, based on similar economic failure statistics. But alas, I hear no one yelling ...FIRE! FIRE! FIRE! The situation is analogous to that of Pastor Martin Niemolla in Nazi Germany:

> "In Germany, they first came for the Communists, and I didn't speak up because I wasn't a Communist. Then they came for the Jews, and I didn't speak up because I wasn't a Jew. Then they came for the trade unionists, and I didn't speak up because I wasn't a trade unionist. Then they came for the Catholics and I didn't speak up because I am a Protestant. Then they came for me - and by that time no one was left to speak up."

Everyone senses trouble but does nothing. It has yet to dawn on anyone in our Contractor base as to what new industries will be targeted...if foreign competition is successful in capturing total market share in the industries so far targeted. Everyone acknowledges the "problem", but does not translate his/her concern into positive action to counter the negative world market trends.

A common disease that afflicts management and government administration the world over is the impression that, in the words of Dr. Deming, "Our problems are different." Many other firms still continue to believe that all the current articles refer to the manufacturing industry; not to their industry.

The truth is our industries are not noticing or does not want to believe world events. By the year 2000, industries in the United States, based on Fortune Magazine statistics, will encounter a workforce made up of 47% women; with people from third world countries holding over 25% of all jobs.

I see no plans being made now by our contractor base to better posture themselves for these changes. In addition, the European Common Market barriers come down in 1992. Countries throughout world and the industries in those countries are realizing that at some point in time there will be a world market. In a world market as well as a domestic market, barriers are dropped and market share will go to those firms having better track record of doing it better or making it better.

Maybe too many people shy away from the dilemma because they remember the echoing message of the movie, "Network Howard Beale, the messenger, voiced his concern regarding the turmoil, "I'm mad as hell, and I'm not going to take it anymore."

Then just as he was starting to turn the tide to get people's (the customer) support, he was stopped by an invisible force (his company's management stepped in). "You have meddled with the primal forces (budget/profit) of nature, Mr. Beale and I won't have it.

There is only one international system. The international system of dollars determines the totality of life." The idea was to perpetuate the least effective and most costly approaches (the competitive bid system). In the end, Mr. Beale - the messenger...was shot. But this does not have to be the fate of our industries if they grasp that traditional approaches get traditional results, and that an improvement process can turn it around.

It is not a question of "watching" one's footing on tradition when climbing the mountain--especially when you see an avalanche of competition that places value on customer quality. The secret is simple. March to the tune of customer requirements. A prime example is McDonalds. McDonalds finds out what the customer needs are, not what it thinks their needs are. Not only do they have a standard of excellence for a clean washroom; they offer "other" services to their customers. They went from offering just burgers and fries to offering salad, soup,...and pizza. All in response to their customer's needs. They do not tell the customer that he is responsible for going to someone else to satisfy his requirements.

The industry response is that they are "concerned" with the trend they themselves see. Followed by...but our industry is different. I personally do not buy this argumement.

Why should they be surprised by the trends? Foreign competitors have already discovered, to their advantage, that many U. S. firms are unwilling to break free from their limited short-term perspectives.

Foreign competition has a value system based on a priority placed on education and a belief that customer service "speaks for itself" in the marketplace. They do not rely on marketing to sell services to the customers. They let customers recognize value based on a firm's track record in quality improvements.

The foreign customer does what Consumer Reports does in this country. They evaluate what a firm says about its product and whether the track record supports and validates the data. Typically, Consumer Reports may look at 20 firms and conclude that only two can back up their claims. When compared to a quality-benchmark, 90% may not even come close to the higher standard.

So it can come to no surprise that the few companies in the United States (around 2% to 3% of the firms) that are successfully applying benchmarks to their supplier base come to the same conclusion:

> The sophisticated customer has discovered that zero-defect results stem from competition based on quality that marches to the beat of a value system (a high benchmark).

ENDNOTES

1) Harris Conversations For the 90s -- The Total Management Story

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3) Quantitative Study of Contractor Evaluation Programs and Their Impact on Project Outcome by Jeffrey S. Russell, Assistant Professor - University of Wisconsin - Madison and Edward J. Jaselaskis, Assistant Professor Iowa State University

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THE B-SPECIFICATION INITIATIVE:

A Streamlined Approach to The Current Acquisition Process

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ABSTRACT

In this fast paced world of constant change, manufacturers continuously strive for product enhancements in order to remain competitive. Car manufacturers compete for sales and resulting profits by attempting to design the most efficient yet practically priced automobile. Clothing designers compete in advertising wars in order to set trends in fashion. Computer manufacturers compete for business by engaging in hardware and software battles. In order to gain the competitive edge, many manufacturers have attempted to streamline their current manufacturing procedures.

The Department of Defense (DoD) has also expressed interest in streamlining current procedures. On January 15, 1986, the Department of Defense released a DoD Directive on Streamlining. DoD Directive 5000.43 illustrates the importance the government has expressed in attempting to control costs and streamline procedures in order to assure system integrity and minimize the risks of programmatic delays. Additionally, DoD 5000.43 formalizes the desire of every program manager to deliver a weapon system that satisfies user requirements yet will reduce costly and unnecessary performance. In addition to ongoing streamlining practices, recent Total Quality Management (TQM) visions concentrated on ways to improve the work environment and/or enhance the government's way of conducting business.

In compliance with these visions, the Electronic Systems Division (ESD) is in the process of implementing a procedural change commonly referred to as the B-specification Initiative. The B-specification Initiative is a procedural change to today's dynamic acquisition environment by which the government delays authentication of the B-specifications thereby allowing the contractor a far greater degree of flexibility in design while still holding him responsible for meeting system level performance requirements. The B-specification Initiative is a significant departure from "business as usual", and therefore both the government and the contractor must have a clear understanding of the guidelines necessary for implementation. These guidelines as well as the rationale and advantages of the B-specification Initiative are discussed in this paper.

INTRODUCTION

Background. The Type B-specification is the vehicle by which the government and the contractor agree on the subsystem software requirements to be implemented and qualified for acceptance by the Government. As soon as the B-specifications become authenticated, thereby establishing the allocated baseline, any changes to the allocated baseline must be handled via an Engineering Change Proposal (ECP) and a resulting contract modification. A contract modification would even be required if a "No Cost" change were to occur. DOD-STD-480A illustrates the procedures necessary to insure proper ECP generation and also describes the approval process in detail.

Since the detail design contained in B-specifications is particularly susceptible to change, ESD has chosen to delay the authentication of the B-specifications. This deviation from the current acquisition process is intended to benefit both the government and the contractor.

Current Acquisition Process. The current acquisition process (refer to Figure 1) begins with a milestone of a contract award followed by an authenticated A-specification no later than System Design Review (SDR). This high level system specification contains the top level system specification requirements necessary to satisfy user needs. The A-specification is closely monitored throughout the acquisition phase of the program and, like the B-specifications, once authenticated any changes to them are handled via the ECP process per DOD-STD-480A. In order to provide the government visibility into the development of the system and to insure that all of the requirements in the A- and B-specifications are satisfied by the contractor, milestones are established throughout the acquisition phase of the program.

Design Reviews, for instance, are conducted during the early stages of the program in order to give government personnel insight into the contractor's evolving concepts and to identify and resolve problems or potential problems. Additionally, Design Reviews provide the forum to insure that the contractor provides continuing visibility into the evolving design, that the government has an opportunity to be active in the trade-off/decision process, and that the key assumptions and constraints are both well-defined and coordinated. Prior to the Preliminary Design Review (PDR), current acquisition practice requires that B-specifications be authenticated thereby establishing the allocated baseline.

Following Design Reviews, software is coded and integrated and then Formal Qualification Tests (FQTs) are conducted. FQTs consist of a comprehensive set of tests used to qualify specific requirements of the B-specifications and are conducted in order to verify the allocated baseline. Prior to FQT, however, detailed test plans and procedures must be written by the contractor and approved by the government. This process requires a strong utilization of manpower and could even result in programmatic delays. Following successful completion of FQT, System Tests are conducted to verify that the A-specification requirements are satisfied. System Test involves various formal tests requiring government review, monitoring, and approval of plans, procedures, and results. Finally, before user acceptance of "the System", an Initial Operational Test and Evaluation (IOT&E) is conducted by the user in order to verify satisfaction of user requirements.

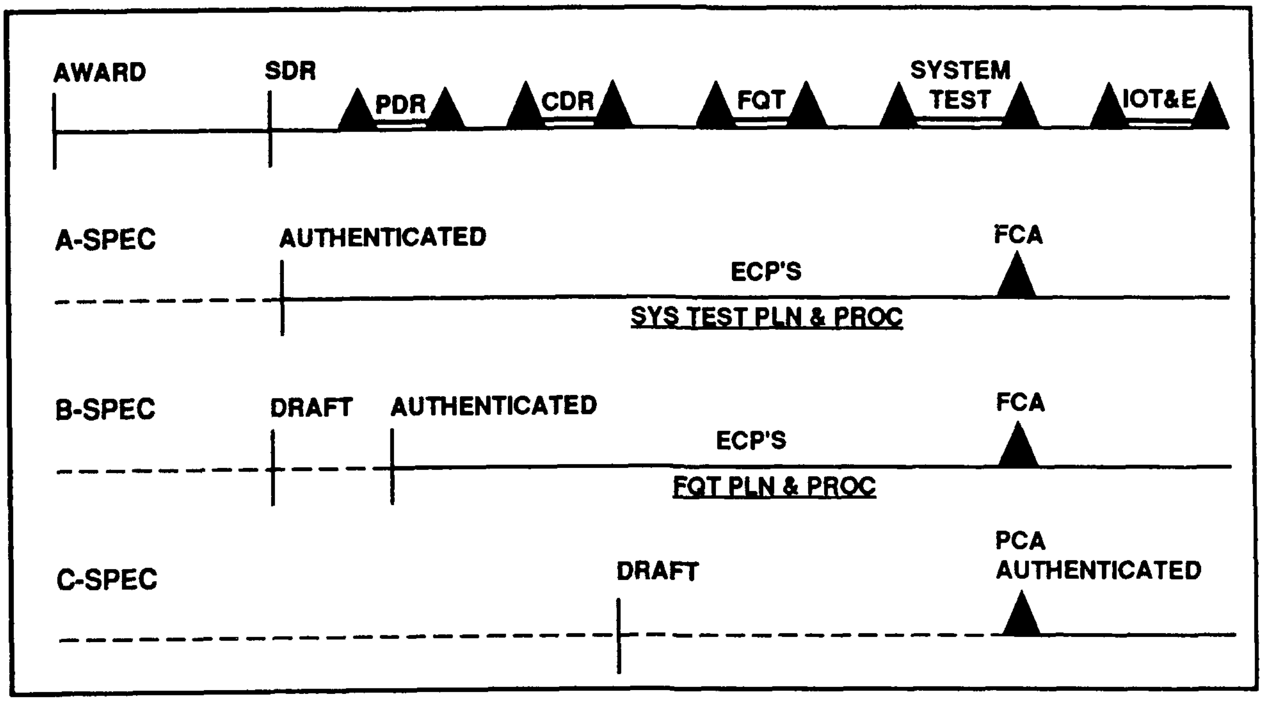

Figure 1 Current Acquisition Process

Revised Acquisition Process. The B-specification Initiative modifies the current acquisition process (refer to Figure 2) such that B-specification authentication is delayed from the PDR time frame until the final Functional Configuration Audit/Physical Configuration Audit time frame; a point in time closer to program completion. The rationale behind this initiative is to support the government's objectives of:

1) Minimizing "Formal" Qualification Testing (FQT)

2) Eliminating the formal Engineering Change Proposal (ECP) process for B-specifications

3) Reducing government involvement in the "How to" details of engineering and test

4) Allowing the contractor flexibility in building the system

ADVANTAGES OF IMPLEMENTATION

FQT Rationale. The essence of the B-specification Initiative with respect to FQT is to modify the test requirements to limit formal government verification of requirements to those contained in the A-specification. It is therefore in the best interest of the government to insure that all critical items necessary to insure User satisfaction with the finished product be included in the A-specification. Formal verification of only A-specification requirements is based on the recognition that confirmation of B-specification requirements is performed by the contractor as an essential step in the development process.

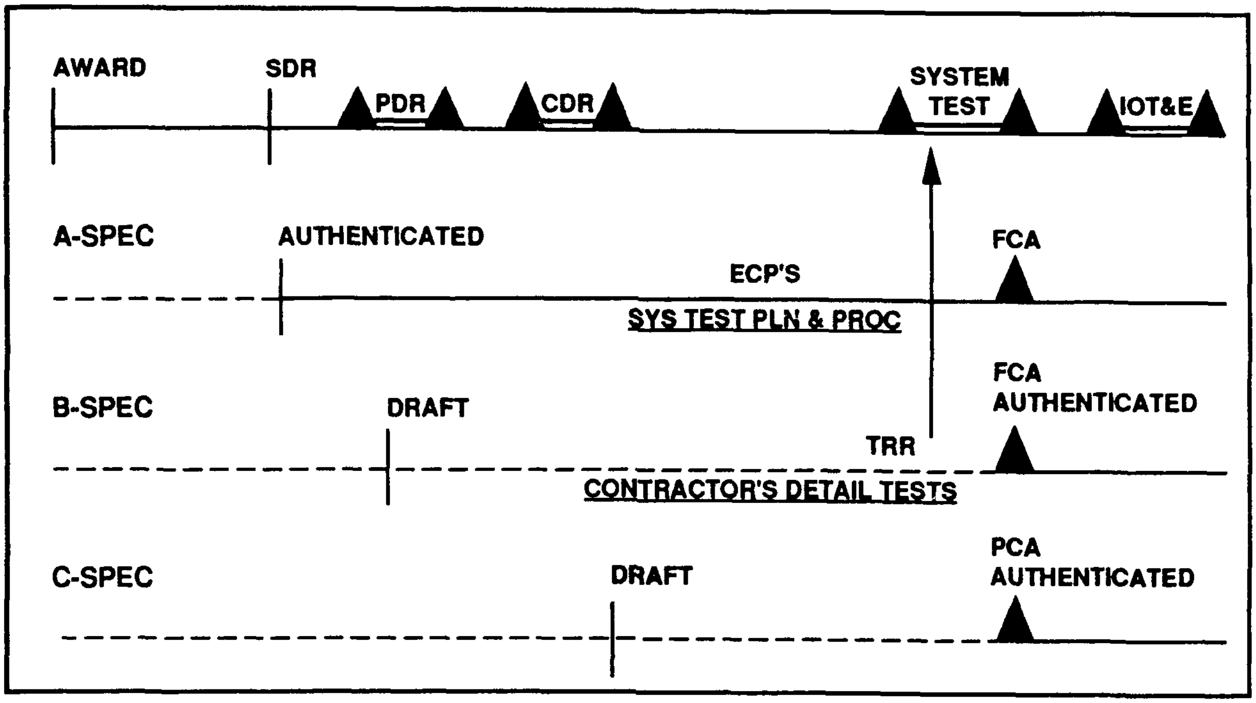

Figure 2 Revised Acquisition Process

One benefit of this approach is the reduction of expenditures by the Government and contractor which would otherwise be required to support formal testing of both A and B-specification requirements. Formal testing would then primarily focus on verification of all A-specification requirements. Additionally, the manpower currently devoted to FQT documentation could be utilized elsewhere. Another benefit would be that the reduced scope of formal testing would take less time thereby reducing schedule risks which may exist and, if schedule improvements result, provide an opportunity for further evaluation of system capabilities which are especially meaningful to the user.

ECP Rationale. The B-specification Initiative also has a positive effect on reducing the formal ECP process. Since the detailed design requirements which are contained in the B-specifications are constantly changing due to contractor iterations of the detail design or other programmatic modifications and since the cost and time associated with the ECP generation and approval process for these changes could become extremely costly and/or result in programmatic delays, delaying authentication of the B-specifications eliminates these potential problems for in-scope changes.

Engineering Rationale. Reducing government involvement in the "How to" details of engineering and test is another key reason for implementing the B-specification Initiative. Once the allocated baseline is established, government personnel tend to direct most of their efforts striving for a "perfect" allocated baseline. The result is that government personnel tend to dictate to the contractor the "How to" details of engineering design. This procedural approach contradicts the DoD Directive on Streamlining which states that government personnel should focus on the "What" that is being developed rather than the "How to" details of development. Delaying authentication of B-specifications allows government and contractor personnel to work closer together in the day to day hands-on operations thereby striving towards a common goal of completing a system which satisfies all top level A-specification requirements. Additionally, providing this increased visibility will require the development of innovative management strategies and supporting policies geared towards achieving the joint goals and objectives of both the government and contractor. This team effort will facilitate the contractor's mission of completing "the System", rather than a probably-imperfect allocated baseline. The end result is that the user should be assured of a higher quality product delivered within program time constraints.

Primary Objective. Although the cost saving benefits resulting from the preceding B-specification Initiative procedural changes could add up to savings of millions of dollars, the main reason for implementation is not cost related. The primary objective behind this initiative is to give the contractor the "flexibility" needed to deliver a better product that meets the user's needs within the time constraints allowed. More often than not, the contractor's flexibility pertaining to the engineering of the system is restricted since government personnel tend to limit the contractor from being innovative in his engineering design. Implementation of the B-specification Initiative gives the contractor this flexibility.

CONDITIONS NECESSARY FOR SUCCESS

General. Implementation of the B-specification Initiative will provide the contractor with the maximum flexibility needed to deliver a system which meets or exceeds all of the requirements set forth in the A-specification. However, delaying authentication of the B-specifications thereby relinquishing formal control of the allocated baseline does remove a safeguard against missing or vague A-specification requirements. It is therefore critical, in order to insure proper implementation, that both the government and contractor personnel have a clear understanding of the conditions necessary for success.

Participation at Contractor's CCB. Government personnel must have insight into the contractor's process and design and they must have a clear understanding of both the operational concept of the system as well as which requirements are mission critical. One method of gaining insight into the contractor's process and design would be to include an observatory participant at contractor Configuration Control Board (CCB) meetings. Observing contractor CCBs will assure the government that the contractor decision process is traceable directly to the government's interpretation of requirements as well as insure that the contractor is following standard contractor practices in maintaining the allocated baseline.

Increase Visibility. The government must retain insight into the quality of the product by occasionally auditing the contractor's internal Configuration Management procedures. In addition to insuring that the contractor is properly maintaining the allocated baseline, this visibility will also help establish a good working relationship between government and contractor personnel which directly effects the quality of the product.

Award Fees. Although work ethics, integrity, and even the potential for follow-on government work should be enough of an incentive for contractor personnel to perform well, that is not always the case. Therefore, another condition necessary for success would be to use robust award fees and/or other types of incentives to encourage the contractor to perform well and work closely with government personnel. For example, a one million dollar award fee bonus, assuming a 10% profit margin, would equate to winning a ten million dollar contract.

Relinquish Control. Another condition necessary for success would be for the contractor to maintain control of the B-specifications. The contractor would therefore be responsible to track and make visible to the government changes to the B-specifications. This would insure that changes being made to the B-specification do not violate requirements specified in the A-specification. If this were to occur, the government Procurement Contracting Officer (PCO) would be responsible for notifying the contractor in writing that this violation occurred. The contractor would then be responsible for taking corrective action.

CONCLUSION

Implementation of the B-specification Initiative will be a Win/Win situation for both the government and the contractor and therefore this initiative should become part of the current acquisition practice. The resources and funds that the government presently devotes to B-specification documentation could be better targeted towards other programmatic issues such as identifying mission critical requirement's and insuring that they are properly tested. Additionally, the governments visibility into the program will be increased enabling the contractor to continuously drive toward a system, rather than a probably-imperfect allocated baseline and finally, the user will be assured of a high quality product delivered and inplace within the program schedule.

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IMPROVING THE RDT&E ACQUISITION PROCESS

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ABSTRACT

This paper provides some insights on the 6.2 RDT&E Exploratory Development technology development programs, their transition to various RDT&E programs, and suggestions for improving this RDT&E acquisition process through more effective and timely transitions required by the RDT&E "customers". Improved communications and teamwork are required between the technology developers and the technology "customers" to improve the complex and diverse weapons systems acquisition process. The author's role in this process is that of the "customer" who receives the output of the 6.2 RDT&E technology base or "tech base" programs.

Significant improvements can be made to streamline and shorten the weapons systems acquisition process by streamlining and shortening the 6.2 RDT&E portion of the acquisition process and providing more effective and timely transitions of "tech base" programs to the "customers". One approach to streamline and shorten the process is currently being implemented by the author in planning and budgeting for incremental product improvements, which are also known as evolutionary acquisition. As compared to the current acquisition process for most weapons systems, this evolutionary acquisition may provide up to a six year reduction in development time.

The author believes that future weapons systems acquisition programs should consider and evaluate the cost benefits of an evolutionary acquisition, which can both streamline and shorten the typical acquisition process. The author challenges the acquisition community to continually encourage and support innovative and creative ideas by acquisition personnel in both the Government and private sector as our national security and national budget demand it.

INTRODUCTION

Background. The timely support for innovative technologies with potential for large payoffs in relatively short time periods is difficult to acquire in the current acquisition environment and infrastructure. The 6.2 RDT&E Exploratory Development technology development programs are primarily focused on long term, high risk, and potentially high payoff technologies that may be incorporated in future weapon system acquisition programs many years after the technology development is completed. For example, a typical weapon system acquisition process generally takes about fourteen years, about three years for technology development, three years for a 6.3A RDT&E Advanced Technology Development (ATD) or Balanced Technology Initiative (BTI) program, three years for 6.3B RDT&E Demonstration & Validation (D&V), and five years for 6.4 RDT&E Full Scale Development (FSD). These estimates are probably optimistic and reflect that of very aggressive acquisition programs. It is very easy to understand why we are providing "obsolete" technologies in our weapons systems when they are actually delivered to our operational field units. The current and projected threats and our various technologies, such as in microelectronics and computer systems are very dynamic and continually evolving at a very rapid pace.

The Honorable John A. Betti, Under Secretary of Defense for Acquisition discussed Secretary of Defense Cheney's Defense Management Report (DMR) to the President which "mandated fundamental cultural changes" for "improved teamwork and communications, managers' participation in the policy-making process, innovation, integrity, and accountability". Mr. Betti pointed out, "Each of us is responsible for improving the part of the (acquisition) process for which we have responsibility". 1/

Scope. This paper provides some insights on the 6.2 RDT&E Exploratory Development technology programs, their transition to 6.3A ATD and BTI programs, and suggestions for improving the 6.2 RDT&E portion of the acquisition process through more effective and timely transitions required by the 6.2 RDT&E "customers". The author's role in this process is that of the "customer" who receives the output of the 6.2 RDT&E technology base or "tech base" programs.

"TECHNOLOGY BASE" PROGRAM

What is a "tech base" program, why do we need it, who manages it, and how does it transition to the "customer"? A "tech base" program is generally focused on developing those technologies that have significant potential for improving future weapons systems, products, and services. These technology programs can improve the systems effectiveness and producibility and provide significant reductions in life cycle costs of current systems. Defense Advanced Research Projects Agency (DARPA) manages some of these programs, such as the "Advanced Torpedo Technology" program. Each Service manages their own "tech base" programs. For example, the Navy's Office of Naval Technology (ONT) under the Office of Naval Research (ONR) manages several programs, such as "Antisubmarine Warfare/Undersea Technology Block Programs" and "Advanced Torpedo Technology Thrust Program". These "tech base" programs are transitioned to the "customers" in various ways. One approach is to transition to a 6.3A ATD or BTI program that has been planned, programmed, and budgeted at least three years in advance of the "tech base" program's transition date. Another method is for the "tech base" program to transition to another "tech base" program. A third approach is to transition directly to the "customer" who then continues the technology development or uses it as an "off-the-shelf" system for incorporation into a larger system. Another method is to continue the technology development until it is ready for transition which may in some cases be a very long time.

EVOLUTIONARY ACQUISITION

How can we better streamline and shorten the weapons systems acquisition process? One approach which the author is currently managing is to plan and budget for incremental product improvements, which are also known as evolutionary acquisition. For some product areas, this evolutionary acquisition may result in a developed product in about three to five years, and more complex developments may take about six to eight years. As compared to the current acquisition process for most weapons systems, this evolutionary acquisition may provide up to a six year reduction using the more conservative estimates.

What do we mean by an evolutionary acquisition? "Evolutionary acquisition is an acquisition strategy which may be used to procure a system expected to evolve during development within an approved architectural framework to achieve an overall system capability. An underlying factor in evolutionary acquisition is the need to field a well-defined core capability quickly in response to a validated requirement, while planning through an incremental upgrade program to eventually enhance the system to provide the overall system capability. These increments are treated as individual acquisitions, with their scope and content being the result of both continuous feedback from developing and independent testing agencies and the user (operating forces), supporting organizations, and the desired application of new technology balanced against the constraints of time, requirements, and cost. Evolutionary acquisition includes the following elements:

1) A concise statement of operational concepts and requirements for the full system.

2) A general description of the functional capability desired for the full system.

3) A flexible, well-planned overall architecture, to include process for change, which will allow the system to be designed and implemented incrementally.

4) A plan for incremental achievement of the total desired capability.

5) Early definition, funding, development, testing, fielding, supporting and operational evaluation of an initial increment of operational capability.

6) Sequential definition, funding, development, testing, fielding, supporting and operational evaluation of additional increments of operational capability.

7) Continual dialogue and feedback among users, developers, supporters and testers." 2/

How does this evolutionary acquisition work? This process can work only with the total commitment, cooperation, and dedication of the acquisition community. One approach is to use Value Engineering contractual incentives, which motivate the contractor(s) to use their Independent Research & Development (IR&D) funds to start the project and results in a Value Engineering Change Proposal (VECP) to the Government. Another approach is to have a Government field activity or laboratory use its Independent Research/Independent Exploratory Development (IR/IED) funding to propose to the Program Sponsor a Government initiated Value Engineering (VE) program. A third approach is to propose an accelerated "tech base" program to the "tech base" program sponsor for rapid development, test and evaluation, and incorporation into an existing weapon system.

All of the above approaches are being implemented in the product improvement programs that the author is managing as part of an overall weapon system product improvement program effort. For example, VECP and VE programs are being implemented for the Guidance & Control (G&C) portion of the weapon system. These VECP and VE programs will significantly reduce or eliminate the increasing parts obsolescence problem for those G&C electronic piece parts that incorporated 1960's and 1970's technologies. Significant reductions in both production and logistic support costs are estimated as a result of reducing the number of parts and circuit boards that will be using the most current microelectronic and computer system technologies. The estimated development time for these VECP and VE programs is about three to five years. An accelerated "tech base" program is being implemented for the warhead portion of the weapon system. This accelerated "tech base" program will significantly increase the warhead lethality of the weapon system and is estimated for completion in about two years. Results of the improved warhead "tech base" program will then be transitioned into a rapid prototype warhead development effort which is estimated to complete in about four years.

CONCLUSION

These weapon system product improvements that have used evolutionary acquisition have been effectively implemented with timely transitions as a result of effective and timely communications and teamwork between the technology developers and the technology "customers". The author believes that future weapons systems acquisition programs should consider and evaluate the cost benefits of an evolutionary acquisition which can both streamline and shorten the typical acquisition process by significant amounts. There are many acquisition personnel in both the Government and private sector with great ideas and suggestions for implementing new technologies in our complex and diverse weapons systems in a effective and timely manner. The author challenges the acquisition community to continually encourage and support innovative and creative ideas as our national security and national budget demand it.

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ACQUISITION EFFICIENCIES FOR THE NINETIES

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ABSTRACT

Management of change in an era of declining resources and an ever-changing world order requires the development of new aproaches to the art of management itself. This paper will discuss the unique techniques and methodology employed by the Army Materiel Command (AMC) in a major undertaking to identify and take action on a series of initiatives to improve the acquisition process. Nicknamed the "Procurement Warfighting Seminar", the methodology features active participation by AMC's top command, procurement, and legal leadership utilizing the discipline of a Contract Policy Model to insure that suggested improvements are well thought out before they are implemented. Individual Initiatives are embedded into a "process/strategic problem" matrix to identify the purpose of the specific items and subsequently implemented through use of a Special Task Force to assure rapid dissemination of good ideas.

INTRODUCTION

BACKGROUND. In December of 1989, GEN William G. T. Tuttle, Commanding General of AMC, directed the formation of a team to conduct a "Warfighting Seminar" at the next Commanders Conference. BG John G. Coburn, AMC's Deputy Chief of Staff forProcurement, and Mr. Edward J. Korte, AMC Command Counsel, were tasked with coordinating the first seminar, whose central focus was to be acquisition. On 26 January 1990, a datacall went forth to AMC's nine Major Subordinate Commands (MSCs) requesting each to submit ten proposed initiatives to improve the acquisition process. The MSCs were instructed to include 4 local initiatives which had already been implemented within their commands, and not more than one initiative which would require legislative or regulatory changes. The remaining five initiatives were to be new concepts suitable for local implementation. A total of 106 initiatives were received as a result of the data call. These were then screened and rank ordered for presentation. On 8 March 1990, the first seminar was convened. Thirty-three initiatives were presented and approved for action. On 21 August 1990, a second seminar was held, using the same pool of initiatives as the first session. Twenty additional initiatives were approved for implementation at the "round two" seminar.

PARTICIPANTS. One of the keys to the success of this exercise was the cast of characters. GEN Tuttle did not state his desires and then step back to let the staff take action. He personally conducted each seminar, with the Commanding Generals of AMC's major subordinate commands serving as presenters of the individual initiatives. This high-level approach virtually guaranteed that each initiative would receive serious consideration in subsequent evaluations and overcome the "not-invented-here" syndrome. The General Officers were assisted in their efforts by AMC's Deputy Chief of Staff for Procurement, the Command Counsel, and key individuals from the Headquarters staff. To preclude the possibility of the seminar results fading into oblivion, as so often happens in efforts such as this, a special task force was formed to oversee and coordinate the implementation of the approved initiatives. In addition to tracking the progress of those initiatives presented in the seminars, the task force evaluated and, to the extent possible, implemented the remaining fifty-three items.

MANAGEMENT MODEL

ACQUISITION INITIATIVES TASK FORCE

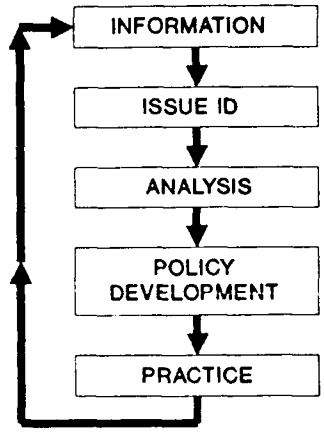


FIGURE 1

METHODOLOGY

CONTRACT POLICY MODEL. Rather than treat the Procurement Warfighting Seminar as a unique activity unrelated to the general mission of the headquarters, this exercise was conducted within the context of a policy formulation model. While the model (figure 1) as displayed depicts the development of contract policy, it is a generic methodology applicable to any discipline. In the idealized case, information is generated which is eventually isolated and identified as an issue which requires a change in policy or doctrine. The information can be in the form of Inspector General or audit findings, a change in law or higher level regulations, or a perceived need on the part of the field activities who implement the policies. Preliminary analysis permits the general identification of those issues requiring action. A more thorough analysis is required to clearly articulate the specific problem and define it in terms of related activiities. Any ripple effect must be foreseen before new or revised policy guidance is generated to assure that only the desired outcome is achieved. The actual policy development is merely the generation of guidance responsive to the matter at hand, which provides the user the information necessary to perform his mission in the most efficient, effective manner consistent with ethical considerations. This phase requires another round of intensive analysis to insure the revised policies are both responsive to the identified need and not inconsistent with other policies. The final phase of the policy development model is application of the revised policy in practice Despite the considerable efforts to foresee potential shortcomings, new policy frequently requires fine tuning after implementing. Experience derived from policy application will in turn result in information, leading to the formulation of new or revised policy, ad infinitum, in a closed loop configuration.

IDENTIFICATION OF COMMON ACTIVITIES. Early in the process it was decided to approach the analysis of initiatives in a systemic manner. While the overall exercise was dubbed "Acquisition Efficiencies", it became evident early on that the vast majority of items dealt specifically with the contracting process, and not the other areas of acquisition management, such as test and evaluation or program management. Figure 2 illustrates how the procurement process was

COMMON ACTIVITIES

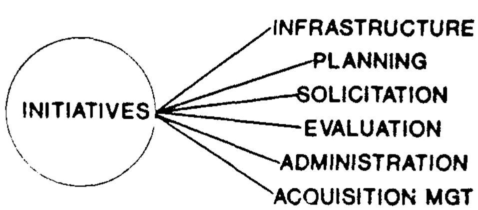


FIGURE 2

viewed as consisting of four "common activities": planning, solicitation, evaluation, and administration. Two other categories were employed: 1) infrastructure - those activities which support or enable the contracting process, such as data processing applications; and 2) acquisition management - those activities which address areas other than contracting. The placement of each of the 106 initiatives into one of the six common activity categories permitted the identification of the particular parts of the process which the participants felt were most susceptible to improvement.

IDENTIFICATION OF STRATEGIC CONCERNS. A second classification of the initiatives was performed, which placed each initiative into one of five areas. As stated above, some aspects of the procurement process are viewed as more susceptible to improvement than others. To avoid the frequent mistake of equating change to progress, the task force related each initiative to one of four areas of strategic concern (see figure 3). These areas were: 1) operational efficiency - those activities which improve the procurement process for the contracting officer; 2) management efficiency - those activities which improve overall productivity; 3) management oversight - those activities which address overall control of the procurement process; and 4) current performance - those activities which involve assessment of a contractor's performance. A fifth category, source selection, was employed which did not clearly fit the mold of a strategic concern, but which was so global in its application as to warrant separate treatment.

STRATEGIC AREAS OF CONCERN

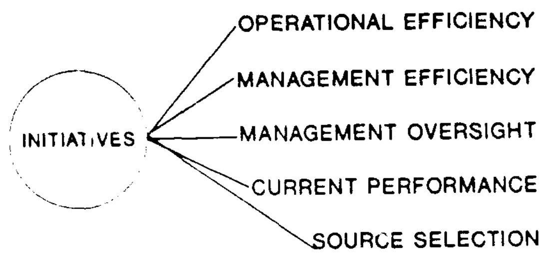


FIGURE 3

ANALYTICAL APPROACH

As stated earlier, a total of 106 initiatives were submitted in response to the data call. When these 106 individual items were stratified by area of "common activities" and "strategic concern", 30 separate projects emerged. The evaluation of these 30 projects constituted "Round 1" of the seminar. A project consisted of one or more initiatives. An overview of the initiatives in the five-by-five matrix described above is shown at Figure 4. Not surprisingly, the common activity most frequently addressed was planning, a legitimate concern of Command-level officers. Likewise, the most frequent "strategic concern" addressed was management oversight. Again, this is the expected area where such a group would focus their attention. Grouping the initiatives into projects resulted in a more

INITIATIVES OVERVIEW

	MGMT EFFICIENCY	MGMT OVERSIGHT	OPS EFFICIENCY	CURRENT PERFORMANCE	SOURCE SELECTION
INFRASTRUCTURE	★	★			
PLANNING		★	★	★	
SOLICITATION		★	★		
EVALUATION		★			★
ADMINISTRATION				★	
ACQUISITION MANAGEMENT	★				

FIGURE 4

efficient analysis by: 1) combining duplicate or near duplicate initiatives into a single task; 2) permitting the specific initiative to be couched in terms of the greater policy issue it represented; and 3) capturing the synergism of several different perspectives on a single subject. Once identified, each project was assigned to a specific action officer for investigation. A detailed plan of action was developed for the evaluation of each project. The policy formulation model depicted in Figure One was then brought to bear on each project. While the acquisition initiatives task force was envisioned as a short term activity, it soon became clear that completion of all projects would require a lengthy period of time. Thus, a small cell within the office of the Deputy Chief of Staff for Procurement was created as a permanent office to oversee the implementation of these and other initiatives. The results of Round 1 are presented in a later paragraph of this paper. "Round 2" of the seminar addressed 20 more initiatives from the original pool for presentation at a subsequent conference. As in Round 1, a proposed disposition was determined for each initiative, with implementation progress to be over-seen and facilitated by the Initiatives Task Force. The major difference in Round 2 from Round 1 was in the way the follow-up was conducted. In lieu of grouping the twenty selected initiatives into projects as was done in the first phase, each action was tracked independently. The twenty initiatives composing Round 2 were arrayed in the same five-by-five matrix as described above and are depicted at figure 5. At the same time, it was decided to give all of the initiatives a second look on an individual basis. This permitted the establishment of individual audit trails for each idea, even though some were completed simultaneously.

INITIATIVES OVERVIEW
ROUND II

	MGMT EFFICIENCY	MGMT OVERSIGHT	OPS EFFICIENCY	CURRENT PERFORMANCE	SOURCE SELECTION
INFRASTRUCTURE		TECOM 6	DESCOM 9		
PLANNING	AMCCOM 7 LABCOM 6	LABCOM 6	AMC 6 TECOM 8 CECOM 4		
SOLICITATION		DESCOM 7 MICOM 6	CECOM 3		
EVALUATION			TACOM 3 MICOM 3		
ADMINISTRATION		AVSCOM 6 AMCCOM 8 TACOM 7			
ACQUISITION MANAGEMENT	TROSCOM 7 DLASAC 4		AVSCOM 10 TROSCOM 10		

FIGURE 5

RESULTS

The results of this effort have been mixed -- not surprising in a universe of 106 separate suggestions. The initiatives themselves varied from local methods which had been found to be particularly effective to proposals regarding new legislation. While the exercise was billed as an "acquisition" effort, the vast majority of the initiatives dealt specifically with the area of contracting. They spanned the breadth of the process - from automation to career management; from approval thresholds to administrative processes. The scope of the individual initiatives ranged from such narrow applications as use of technical review boards in specific situations, to such far-reaching ideas as a proposed statute to prohibit manufacturers from using other than original part numbers, thereby improving the Army's ability to buy spare parts effectively. During the conduct of the seminars, each initiative was presented, discussed and assigned a disposition status, based on a vote of the total group. The disposition categories were: 1) Approved for implementation across AMC; 2) Further study required prior to final decision; 3) Approved for implementation at the option of the individual Major Subordinate Command; and 4) Approved in concept, forward to Department of the Army. Category 3 recognizes that ideas or techniques which may work well in one commodity or environment may not be suitable in other environments. As stated earlier, a specific disposition has been developed for each of the 106 initiatives. While space considerations preclude discussion of all of the individual actions, a statistical summary can be provided. As of the date this paper went to press, 76 actions had been coded complete.

An additional 28 were still in process. The "in process" category is an open-ended status, in that certain of those actions may require DOD or Congressional action which could take years to obtain. A note of caution is also required with respect to the term "completed". Initiatives were coded complete when any form of final resolution was obtained - a rejection from Headquarters Department of the Army of a proposal did not constitute the desired outcome, but did "close out" the initiative. The Acquisition Initiatives program was not designed to re-invent the wheel. Whenever an initiative lent itself to resolution through existing channels, those channels were employed. A good example of this principle is in the area of Acquisition Plans (APs). Four different activities (Headquarters AMC, the Missile Command, the Test and Evaluation Command, and the Troop Support Command) submitted initiatives designed to streamline the preparation and processing of APs. During the same timeframe, Headquarters, Department of the Army was forming a Process Action Team to review and recommend changes to regulations governing APs. The Acquisition Initiatives Task Force action in this case was merely to pass the initiatives to the AMC member of the DA team and follow up on the outcome of the DA directed exercise. Five initiatives were likewise "disposed of" in the area Justification and Approvals. While in most cases the resultant changes were not exactly what the initiator requested, their suggestions did receive full consideration from appropriate levels in a timely manner. Individual initiatives worthy of note include a "personnel oriented" action at the Aviation Systems Command which involved the "certification" of high quality employees. This formal system of recogni-tion of high quality technical competence is an outstanding example of TQM, in that the employees are not certified based on school attendance or special projects, but on the production of high quality contract packages. This bottoms-up approach is classic process improvement based on customer satisfaction.

CONCLUSION

The AMC Acquisition Initiatives program is not going to change the world. It is, however, a process worth keeping and proliferating. The Policy Development Model discussed above is applicable to virtually any discipline or area. When energized by the high level involvement of command personnel, this methodology can lead to significant improvements in our business processes. The acquisition community lives in a fluid world, constantly rocked by changing laws and rules governing the way we must perform our jobs. Despite these environmental changes, we must continue efforts to devise improved procedures for efficient operation. The methodology described in this paper can assist organizations in this process improvement effort.

ACKNOWLEDGEMENT

The foregoing paper is the result of a small army of dedicated professionals. The author wishes to thank the individuals who comprised the Acquisition Initiatives Task Force: Mr. Verne A. McKamey, Ms. Susan L. Schneider, Mr. Daniel J. Breen, Mr. Wayne M. Avery, Ms. Christine M. Alexander. Mr. Aaron M. Richardson, and Mr. Daniel Raleigh.

TOTAL QUALITY MANAGEMENT (TQM)

and

TOTAL QUALITY CONTROL (TQC)

A QUALITY ETHICS MODEL

FOR MANAGERS

Forrest Gale, Defense Systems Management College

ABSTRACT

Quality and Ethics are subjects that are inextricably intertwined in both theory and modern management practice. Ethics informs choices enacted beyond the realm of law, regulation, standard, rule, and procedure--that twilight zone in which many daily defense acquisition decisions are made. Moreover, there are behavioral as well as decision aspects embedded in ethics dilemmas. Quality, an attribute of product or service arising from a focus on customer wants, needs, and ultimate satisfaction, can only be achieved and then continually enhanced if the framework in which it is pursued is ethically derived. This paper reports on the results of action research on quality and ethics that culminated in the first Department of Defense Executive Ethics Workshop. Out of this research has come a clearer understanding of the ethical underpinnings of quality management. Moreover, though quality choices are often made in an ambiguous environment wherein the ultimate quality impacts are not easily discerned, the right choices invariably generate from an ethical base. This paper describes a Quality Ethics Model that can be used by managers and leaders as a foundation upon which to base choices and guide subsequent actions focused on quality of product and service provided to both organization-internal and organization-external customers.

INTRODUCTION: THE BEHAVIORAL FOUNDATION OF ETHICS

As our experience broadens in the practice of quality transformation in our organizations, the role that behavioral dynamics play in quality transformation has become more and more pivotal to success. Undergirding the practice of quality by leaders, managers, and professionals in any organization is a set of core values that inform the moment-to-moment choices that are made. These core values, together with the environment, leadership style(s), perceptions about the physical/psychological world, needs of the individuals in the organizations, etc., constitute components of the behavioral system wherein quality is enacted (or not).

Personal and organizational (group) perceptions, together with needs and environmental influences, are dominant drivers of quality behavior and performance. Personal perceptions are derived from a person-unique blend of experience, paradigm, personality, need dominance, and cultural (group) interaction. Within the perceptual framework of the individual are embedded childhood experiences, injunctions from parents and other early authority figures, and archetypes of consciousness that seem to be derived from species-specific electrochemical and topological structures within the brain. It has been theorized that the latter in some way relate to survivability of the species and have/have had specific impact on environmental mitigation or transaction during the evolution of the species. Freud's prototypes and Jung's related archetypes may be classified as attempts to describe and characterize these apparently culture-transcendent influences.

Wilfred Bion, a British psychiatrist, has developed theories of group behavior which are based on these so called "prototypes" of the formative unconscious as they are collectively realized in complex <u>group</u> behavior. A group ethic or set of group values that define the norms and establish the underpinnings upon which group culture rests, is postulated. This ethic, while informing group process, is seen as primarily influenced moment to moment by group assumption mental states which derive from the aforementioned prototypes. Bion's theory is descriptive rather than predictive. However, he does characterize a group growth state he calls "the assumption mental state of work" by providing an observationally derived attributes model based on thousands of group assessments. The Bionic model closely aligns with the author's observations of the principal state of a number of high performance work teams within the Department of Defense and in industry.

It is widely thought that the core (ethical) values that inform our choices are established within the individual early in life. Beliefs, assumptions, experiences (whether interpreted with fidelity or not) and paradigms establish the value set with which we enter the adult years. It is also widely believed that modification of ethical values either does not take place in adult life or is so difficult to effect as to be rare in human experience (i.e-If your parents didn't teach you, you won't get it when you're an adult). Michael Josephson, of the Josephson Institute, an ethical think tank and service organization, avers that exactly the opposite is true. Mr. Josephson maintains that ethical development proceeds at a rather uneven pace <u>throughout</u> a person's life. His widely published research suggests that there is a period of rapid ethics-base establishment in childhood, a further testing and evolution during the teens, and another developmental period in the early adult years (20s). Yet another period of possible growth and change takes place prior to entry into the middle years (late 30s), and a further development and rebirth can take place if the individual reaches the so-called senior period in life (late 50s upward). Josephson has evidence that leads him to state that the growth and development of personal ethics can be catalyzed by appropriate formal adult education mechanisms as well as by the traumatic experiences that we know can cause a reexamination of self, and that hold the potential for a measurable shift in core values.

ETHICS IN THE PUBLIC SECTOR

Ethics is a broadly misunderstood issue in the United States Government. Public law, rules, regulations, procedures, and standards are seen as ethical doctrines. Conformance to these doctrines is often seen as comprising the necessary and sufficient boundary of ethical behavior. But anyone who has spent any time at all working in public sector organizations knows that unethical/inhumane behavior is often present even though the laws, rules, regulations, procedures, and standards are being followed "to the letter." Consequently, most practical public sector managers realize that it is simply not possible to cover with written law, rule, or standard all the situations wherein ethical decisions must be made (i.e.-where there is a clash of values). Such a nightmare jungle of rules would probably slow or freeze needed action while still being inadequate and incomplete. Standards of Conduct notwithstanding, it simply isn't possible to legislate ethics.

Ethics is about the practice of applying core values to decisions that lie outside the realm of law, rule, and regulation (i.e.-the so called "twilight zone" of managerial problem solving and decision making). To this end, the author, working with Michael Josephson and others, was recently involved in the design, development, and conduct of an Executive Ethics Workshop in which senior Department of Defense executives were given the problems of current importance in the Defense Acquisition business and asked to apply core ethical values to their resolution. The workshop was very successful by any measure, and a post-event assessment yielded the following list of reasons why this was so:

CREDIBLE PROCESS LEADERSHIP	• A skilled & credible class process leader.
STUDENTS TREATED AS ADULTS	• An educational <u>experience</u> wherein executive participants were treated like adults (little/ no didactic instruction).
SIMPLE MODELS AND PARADIGMS	• Simple but powerful problem solving/decision making models were presented (easy to remember)
IN CLASS APPLICATION OF PRINCIPLES	• The opportunity for experiential employment of decision model(s) and ethics principles cemented and reinforced the learning.

REAL LIFE SCENARIOS

- The case(s) used for experiential exercises were real--they came from the real life context-relevant experience of leaders who had "been there" (we picked one such case out of 15 that were developed for the workshop based on precursor interviews with currently active DoD executives).

SMALL GROUP PROCESS

- Utilization of a small peer group workshop process--this broadened and deepened the coverage and exposure of ethical principles and the ethical problem solving/decision making process.

AVOIDANCE OF LAW & CONDUCT "PREACHING"

- A deliberate avoidance of preaching and the reading and belaboring of standards of conduct and public law; the design rule was: If an executive can read and easily understand it, don't present it. Ethics is the twilight (gray) area <u>beyond</u> law and regulation, <u>not</u> what is "legal."

EXECUTIVE LEADERSHIP ENVIRONMENT

- A low key, relaxed, informal yet thoroughly professional tone, pace, and environment in which the comfort index for our most senior leaders was very high. This "low defense" atmosphere resulted in a greater probability of participative experience sharing; reflective ethics thinking; resulting penetration of the individual executives' perceptual filter; subsequent internalization and shift in ethics perceptions; and increased likelihood that consequential acts resulting from these perceptual shifts would reflect a deeper understanding and appreciation of ethics precepts and practices.

SUBJECT PERSONALIZATION BY DESIGN

- A carefully structured design crafted to leave the executive--at the end of the experience--wanting more, by creating a high-probability-of-success event at the end of the workshop. This event had built-in emotional hooks which were designed to involve each participant leader emotionally, and thus personalize the issue of ethics. This event also was designed to cause the thoughtful leader to seriously question the adequacy of his/her ethical performance, regardless of the high ethics-related self-regard most executives were likely to bring to the workshop. The outcome desired was thus to cause the formation of an internal motive force impelling an enacted improvement in ethical behavior and executive problem solving/decision making, rather than merely a further self-validation of ethical adequacy.

Discussions and thinking resulting from this workshop experience moved the author into an examination of the ethical underpinnings of quality, and--subsequently--to research that led to the quality ethics model which is reported in this paper.

QUALITY AND ETHICS

What executives do
What they believe and value
What they reward--and whom,
are watched, seen, and minutely interpreted throughout the whole organization. And nothing is noticed more quickly--and considered more significant--than a discrepancy between what executives preach and what they expect their associates to practice.

- Peter Drucker

Peter Drucker, the elder statesman of modern management theorists, has stated above a focus on an ethical issue which is embodied in a basic principle of quality leadership practice which is, "walk like you talk." This example is typical of the intertwining of core ethical values and the principles of quality practice. If (as that grand old man of quality, Edwards Deming implies in his 14 points of Quality Transformation), quality transformation is mostly about management, leadership and behavior, then it is also mostly about ethics. But organizations are made up of groups of individuals. Indeed, a primary dynamic of the practice of quality in an organization is the cross-disciplinary teaming that is necessary to address continuous quality improvement in complex processes whose stakeholder-enactors reside (often) in many different organizations. Do ethical values form the baseline for problem solving and decision making in these cross-functional interdisciplinary teams? The answer is, of course, in the affirmative. It is simply not possible to successfully work and sustain quality transformation, behavioral change, continuous, process improvement, and collaborative customer satisfaction in an unethical manner.

Ethics are the base component of the organizational culture (beliefs, agreements, perceptions, assumptions, values, goals, capabilities, etc.) that distinguish one organization from another. The mosaic of individual ethical values sums synergistically with the environment to form the culture, the quality culture of the organization. If quality has primacy and is paramount in a public sector organization, quality ethics also have primacy; and they are a behavioral driver manifest in their overt realization.

Michael Josephson has said, "the true values of an organization are reflected in the multitude of small things that the organization does or allows to be done. What it encourages, what it allows, what it appears to know and not know, send clear messages to vigilant employees as to what is really important."

So, what are these values, and how do quality leaders and managers engage and transmit these values to the transforming quality organization?.

THE CORE VALUES OF QUALITY ETHICS

Ethics is a body of principles of right and good conduct. It is the individual and collective moral values of the members of an organization. It is the basis for making quality choices. It is the template of values a quality manager/leader places on what he/she perceives to be so, to inform the quality choices to be made. It is the bedrock of moment-to-moment interpersonal behavior in which choices are made for and against the ultimate quality of product or service provided to both internal and external (outside the organization) customers. But managers and leaders resist an open discussion of quality ethics. One common barrier is this perception: that by discussing ethics the manager/leader is somehow admitting ethical deficiencies. This, again, stems from the belief that if you don't get a good ethical foundation when you're young, you will be deficient in the adult practice of ethics-(i.e.)-if you don't know what's right/wrong and have to talk about it, you are prima-facia deficient in ethics. So, managers and leaders want to be trusted, and not be sermonized or preached at on the subject of ethics. But trust--an essential component of quality practice in organizations--is earned. And (catch 22) trust can only be earned if the leader/manager behaves ethically over time. So we are back again to the issue of ethics and core values in quality leadership behavior.

My research with hundreds of executives attempting to initiate quality transformation in their organizations is that ethics is a very difficult issue with which to come to terms. Typical ethics-related perceptions are detailed in Figure 1.

The perceptions cited in Figure 1 provide a convenient and apparently common rationale for choice that results in the decision maker's self-permission to ignore core ethical values. Ten core ethical values that seem to be universally cited in the literature of ethics (Josephson and others) are:

1. Honesty
2. Integrity/Character
3. Promise-Keeping
4. Fidelity
5. Fairness
6. Caring for Others
7. Respect for Others
8. Responsible Citizenship
9. Pursuit of Excellence
10. Accountability

Upon these ten values are based all the ethical behavior that supports a quality transformation in an organization. We will briefly examine each of these values as it seems they should be practiced in a transforming quality organization. The models for ethical quality behavior that follow are derived from conversations and interaction/observation with

QUALITY LEADERSHIP BEHAVIOR: TYPICAL ETHICS PERCEPTIONS

Perception Issue	Communication
Self-Image Motivator	"I am more ethical than others."
Self-Deception	"Everyone does it;" "to get along, go along;" "they don't understand."
Self-Indulgence	"I'm doing it for them."
Self-Protection	"I'm avoiding sanctions, unpleasantness."
Self-Righteousness	"I'm morally superior; I can therefore pretend to include (but ignore) the opinions of others."
Faulty Rationale	Overestimate costs/risks of doing right thing; underestimate costs/risks of not doing right thing. Short term payoff is more desirable, and necessary to survive.

FIGURE 1

hundreds of quality leaders as they have pondered and reacted to quality dilemmas in which the ethical component of choice was recognized and actively explored.

1. The value of honesty in quality organizations seems to invoke images in managers minds of truthfulness, candor, straight forwardness, and sincerity. An important condition precedent to trust (an absolute necessity in the successful practice of quality), honesty has two components that were repeatedly mentioned by managers in the authors research. These components are external honesty and internal honesty/consistency.

It seems that self-deception (based on all the previously cited influences such as needs, paradigms, etc.) is antithetical to effective quality practice. Self-deceptions are often transparent to the observer. They indicate an ambiguity/ambivalence about the follow through on quality issues, and weaken the quality leaders ability to coach/move organizations forward in the transformation process. External honesty is a bedrock requisite to quality practice. The penalty for a deficiency here is simple and direct: lack of quality practice on the part of those led and managed. "Going through the motions" is a common dynamic

ENVIRONMENTAL (CAUSES) ELEMENT	COMMON MANIFESTATION	EFFECT
CONFUSION	- Pronouncements of certainty - Quality "experts" emerge	Multi-directional or aborted action. Going through the motions.
FEAR	- Statements of support (inability to act)	Lots of talk; No action.
APATHY	- Depersonalization of quality - Projection of quality antipathy - Delegation of quality leadership/action responsibility - Expectation of quality as a short term focus	Widespread talk of "they" or "them" and fingerpointing. Labeling of quality as "nothing new."
EGO GRATIFICATION NEED	- Self perception of quality excellence - Self avowed - "already doing it" - Wild (surface) enthusiasm	No need for change; current actions produce full satisfaction of supplier.
SOCIALIZATION/ AFFILIATION NEED	- Multi-group affiliation with the status quo	Busy - too busy for quality. No money, time, people, etc. available. We'll wait this out. The fad will go away.
SAFETY NEED	- Cautious; wait and see; do only if others do	Static environment quality is talked about, not practiced. If I do it, then.... (negative fantasy).
SURVIVAL NEED	- Grudging willingness to do - Wild (surface) enthusiasm - Failure is predicted, expected.	Negative emotional climate. Fear; punishment/loss are expected; secret apprehension; dire predictions.

FIGURE 1

wherein honesty is an ethical issue. Quality results simply aren't there for the customer in the long term.

2. Integrity and character have much to do with the quality manager/leaders' practice of quality. The quality manager must embody quality in his/her behavior and, above all, in the choices made. Such a common management issue as resource allocation and control either reflects quality considerations or it doesn't. The courage of the leader/manager over an extended period of time is also at issue here. Does he/she stand up for the hard choices that are choices in favor of quality? Is he/she principled, and does he/she have the courage of quality convictions, rather than being simply expedient, hypocritical, or wavering/wishy-washy on quality issues? A fine example of this in many of our current organizations in DoD is the attention given by managers to training. In the quality ethos, people are the most valued and precious of quality resources. For adequate process performance and resultant quality and narrowing variance the human resource must be continuously developed. When resources become more scarce (as is presently the case) the conventional wisdom dictates a proportionately larger cut in "nonessential" functions. The counter-intuitive (quality) view holds that one must increase rather than decrease education and training resource expenditures in time of economic stress, because one will be asking the human resources (perhaps fewer of them) to do more with less as they enact processes, and yet maintain or improve quality at the same time. This could only occur if the human resource were more robust, more capable of exerting greater leverage on the quality system; and that could only come about through greater empowerment/development of the human resource base. It is instructive to note what happens to the typical DoD organizations' training budget as economic stress is experienced.

3. Promise-keeping is another condition precedent to trust. Keeping commitments that were fairly negotiated is a continuous problem for many managers and leaders. The obligation here for quality managers is to not enter lightly into quality agreements. But, once made, quality agreements scrupulously honored earn dividends far beyond the act. A quality manager's word is his bond. Unavoidable breaches are clearly, quickly, and unambiguously transmitted to the customer (internal and external) and immediate attempts to reestablish the agreement are undertaken. Quality agreements are honored more in the observance then the breach in transforming organizations. Many managers sampled contrasted this with common practice in their organizations.

4. Fidelity to managers in the research sample meant being loyal and steadfast to agreements, commitments, goals and objectives. The

successful quality lender seems to maintain a position of quality that is primary in his/her decision process. Communication of this position is ongoing and is buttressed by decisions and actions that are consistent with the communications sent. Quality managers seem to maintain over time an organizational quality position that is constant with relation to external customers, the outside environment, and the vision he/she articulates of the future (i.e.-where the organization is headed). This positioning develops (as in the Bennis strategic leadership model) a further element of trust in the organizational climate. The resultant effect is a synergistic multiplier in terms of trust and support for the vision as it is "behaved" by the ethical quality leader.

5. Fairness in the minds of managers sampled by the author invokes terms such as just; equitable; open; consistent; uses appropriate methods and criteria in making choices; is not arbitrary, closed, or prejudiced; is a very skilled listener who uses what she/he hears as an important factor in making choices. Managers, however, have a difficult time with this value when it comes to performance assessment and reward systems. The most advanced quality-competitive organizations in the private sector are working hard to develop peer group (read "quality team") reward strategies that possess components of peer rating, group performance, and contribution to group performance. These kinds of reward strategies are alien to the paradigm of individual assessment and reward that dominates current organization practice. As organizations move toward this new approach (while still recognizing individual achievement), practice of the fairness value will become pivotal to success.

6. Caring for others is an ethical value that seems to clash with "businesslike" or "professional" practice in many of our organizations. Such words as "compassionate," "kind," "considerate," and "unselfish" seem foreign to many a normative organizational and climate. Yet these are the words quality managers in our research population most often use to describe an ethical value which is often found in practice in world leading quality organizations. The clash between the collective consciousness of Japanese culture (with its respect for the welfare of the group) and the singular American focus (on the welfare of the individual) is, of course, manifested in the quality practice of organizations in these two cultures. Even so, it has been observed by many managers that harshness in both systems has resulted in long term damage to individuals and--ultimately--to the capacity for quality achievement and competitive advantage in the global marketplace. Our managers are telling us that the resilience and ability to "roll with the punch" in times of economic and performance stress often depends on the depth of compassion the organization

manifests in its exchanges with internal customers.

7. Edwards Deming cites respect for the worker as a major component of quality transformation. Deming says that individuals want to do their best, will take pride in their work, and will produce to the full capacity of the processes they enact if management will only hire them, properly match them to positions, train and equip them adequately, create a management systems structure to support their achievements, and adequately resource the processes that they enact. Management, according to Deming, must also utilize their expertise in the design and continuous improvement of the enacted processes. Thus, the respect for the dignity and autonomy of others and the <u>absence</u> of brutal, patronizing, or callous behavior that characterize the best practice of this ethical value seem to be a cornerstone on which the successful management and leadership of quality must be based. Managers generally agree, but there seems to be some confusion regarding the concept of tough minded management (in the sense of dedication to and perseverance of quality and other supporting objectives) and tough minded management that is tough on people (i.e.-chews them up, angers and humiliates and degrades them, intimidates and coerces them, etc.). The latter practice is all too common in many of our organizations, though it is--managers tell us--often masked in a veneer of cold civility or in a pretense of regard belied by the practical decision process.

8. Responsible citizenship refers to the ethical value that impels observance of laws, rules and regulations. What is strongly implied here is respect for others and the observance of behavioral guidelines that take into account the welfare and effect on others of <u>one's</u> own actions. In the quality ethos responsible citizenship has to do with consideration of the effect on others of the violation of agreements (policies, laws, principles, rules, regulations, procedures), and most especially the effect on the resultant quality of product or service provided to <u>both</u> external <u>and</u> internal customers. The world class quality leader/manager is a quality citizen, and the consideration of the results of actions violating conditions and agreements must always be weighed against human/quality outcomes. A core analytical technique of quality practice is the identification of root causes. This ethical value finds its quality practice analog in the identification of these causes and their effect on both physical and human process outcomes. Responsible citizenship seems to be quality sensitivity in its highest degree of practice.

9. The pursuit of excellence ethic is embodied in two major themes of quality practice. (1) Continuous process improvement; and (2) Customer satisfaction. In the former, the many small incremental additive effects of process

improvement are focused on gains at the margins that are aimed at providing and maintaining a competitive edge and hence a position of excellence. Whereas before the point of diminishing returns became the "good enough" target of management intent, now the transforming quality organization sees quality gains, however small, as opportunity for excellence. The quality glass is thus always half full rather than half empty. The second theme recognizes the great equation of quality (i.e.-needs plus wants equal customer satisfaction) but adds a third factor, Deming's so called "customer delight." The customer satisfaction equation previously elucidated cites the usual customer need as an excellence factor. But in the highly competitive global marketplace (and the current defense environment of declining resources) an organization (or individual manager) must be able to meet quality "needs" just to get in the game. Much of current market competitiveness and differentiation is involved in the second factor, customer "wants". Satisfying more of the customer's "wants" cheaper, faster, and with less variance (higher quality) is what current competitiveness is all about. Customer "delight," the nee plus ultra of quality achievement, stems from the knowledgeability and world class expertise of quality suppliers. The world class supplier/ manager/leader is constantly working and improving his/her ability to divine what a customer wants beyond current knowledge or expectations. This is the "make a market" leadership that created the microcomputer chip, the VCR, Federal Express overnight service, and a host of other products and services the average customer could not at the time of development conceive of wanting or needing. The effect of the application of the pursuit-of-excellence ethic is that wants are constantly becoming needs, and thus a requirement for suppliers who want to "stay in the game" of competition. Also, delights quickly become wants and, ultimately, needs. Figure 2 refers.

10. Accountability, the last of the ten core ethical values, plays out in quality practice as a behavior founded--again--on trust. In the enactment of processes things may go wrong. In a practicing world class quality organization, the individual is never the initial focus of a quality problem. The process is <u>always</u> examined first. The cause of the quality anomaly is determined (by a process action team or similar group of stakeholder enactors) to be due to a general (systemic) cause or a special (one time, random, environmental) cause and through analysis of data is identified. If the cause is a resource deficiency, and the resource is human, the examination takes a different tack. The process design tools used, other resources, training and skill level, and job design and match are all examined. If a causal deficiency is found, management--not the individual--is responsible <u>and</u> accountable for correcting the deficiency. This is in

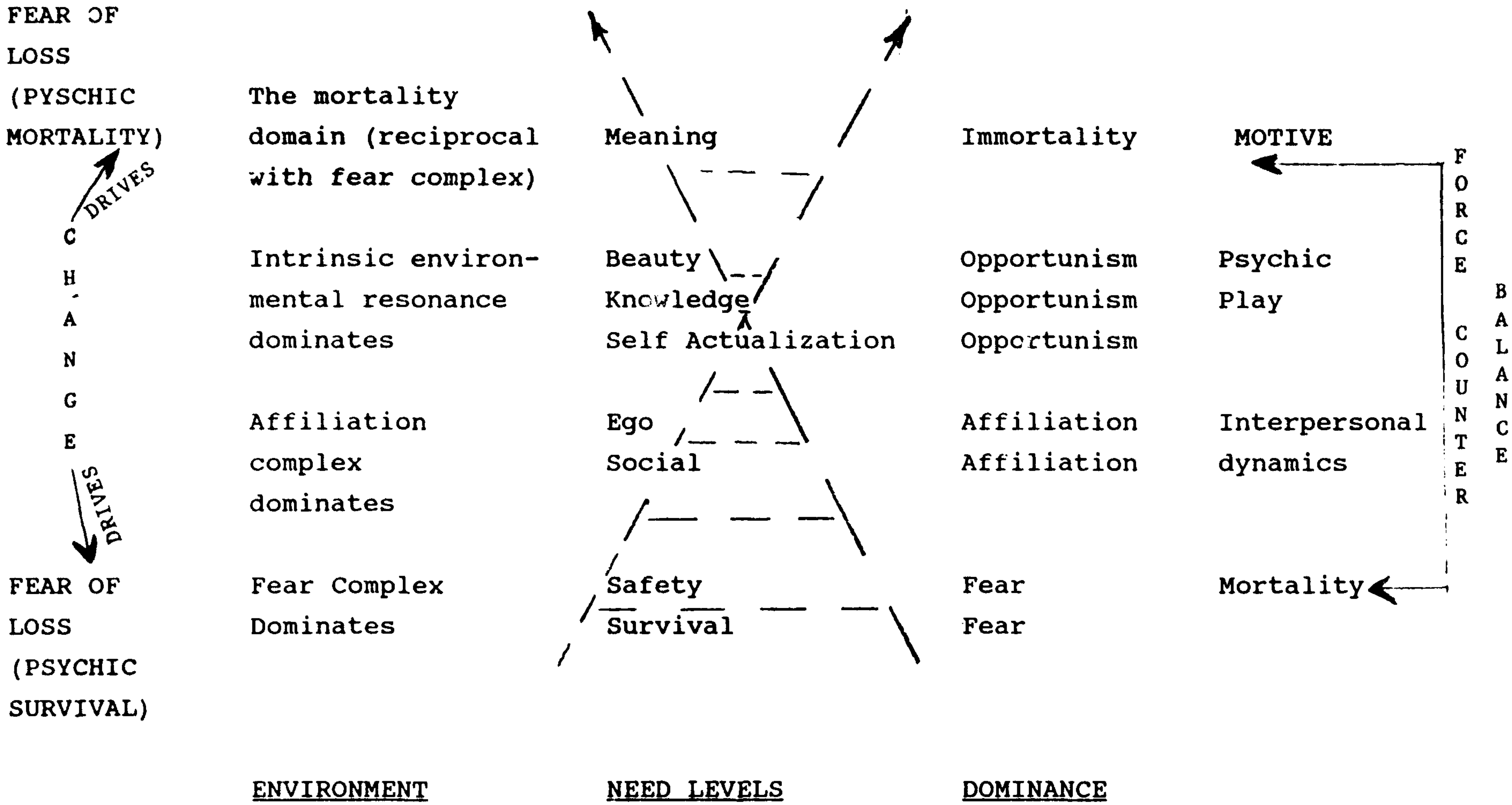

FEAR OF LOSS (PYSCHIC MORTALITY)
DRIVES
CHANGE
DRIVES
FEAR OF LOSS (PSYCHIC SURVIVAL)
The mortality domain (reciprocal with fear complex)
Intrinsic environmental resonance dominates
Affiliation complex dominates
Fear Complex Dominates
Meaning
Beauty
Knowledge
Self Actualization
Ego
Social
Safety
Survival
Immortality
Opportunism
Opportunism
Opportunism
Affiliation
Affiliation
Fear
Fear
MOTIVE
Psychic Play
Interpersonal dynamics
Mortality
FORCE COUNTER
BALANCE
ENVIRONMENT
NEED LEVELS
DOMINANCE

Figure #2

keeping with the "most valuable resource" view of people, and manifest evidence of an understanding that management and management alone is responsible for all the incidents of the production of quality products and services. It should also be noted that, during the analysis, accountability for various process sequences and their subproducts and services rested with the members of the process action team--the investigating cross-functional team. Hence, an important ingredient of the process of quality analysis and the actual enactment of quality is due to the observance of this ethical value. While a quality principle states that responsibility and accountability for quality cannot be delegated by management, we can also say that accountability for quality on the part of each and every person in an organization must be established, internalized and accepted, and maintained. Quality transformations begin with each individual, but enactment requires the collective effort of all people in an organization.

TOWARDS A QUALITY ETHICS MODEL FOR MANAGERS

Out of the comments, conversations, shared and opined practices and anecdotal evidence offered by hundreds of leaders and managers struggling with quality has come the leaders quality credo of Figure 3.

Leaders Quality Credo

- Maintain Constant Purpose
- Invest Time
- Create Ethical Climate
- Customer Needs Drive
- Use Quality Teams
- Remove Quality Constraints
- Involve Everyone
- Design-In Quality
- Train and Educate
- Focus on Process Control
- Control Variance
- Continuous Organizational Learning
- Remove Quotas
- Provide Quality Resources
- Use Quality Tools
- Continuously Improve

FIGURE 3

To apply this credo, many decisions must be made. Since the utility of ethics primarily lies in informing choice and subsequent action in the so-called "grey" areas of decision making, how should quality decision makers act? In other words, what might a quality decision making model look like which would incorporate: (1) the core ethical values; (2) the quality leaders credo; and (3) a quality ethics decision framework?

An ethics decision framework that appears to have utility is that of the Golden Kantian Consequentialism (GKC) model. The GKC model is outlined in Figure 4.

How is this model to be placed into action by the quality leader? Consider a typical decision, that of budgetary resource allocation among competing alternatives. Our managers have to told us that the application of the model to quality practice might work something like this:

PROTO QUALITY ARTIFACTS

INSUFFICIENT PSYCHO MASS

CHANGE

EARLY (RESISTANCE) PHASE	LEADERS BEHAVIORAL FIELD	MID-TRANSITION PHASE	LEADERS BEHAVIORAL FIELD	MATURE (QUALITY GROWTH) PHASE
•Survival needs dominate •Safety needs dominate •Precursors to affiliation need dominance developing •Confusion widespread •Antipathy widespread •Apathy widespread •Trust level low •Old paradigms dominate •Quality perceived as "outside" the individual	QUALITY INITIATION	•Affiliation needs dominate •Traumatic instances of survival/safety needs occur (accompany failure and personnel turbulence) •Precursors to dominant opportunism developing •Trust level (nascent) building •New paradigms recognized •Quality recognized by critical mass as "internal" to the individual	QUALITY INITIATION	•Quality opportunism dominates •Trust level high •Quality trauma dispensed/defused as it occurs (mechanisms) •New paradigms established •Precursors to "meaning in quality" developed •Quality internal-group linkage dynamic is normative
PRINCIPAL	LEADER	PSYCHO-TASKS		
•Barrier Breaching •Critical psychic mass development •Traumatic incident mitigation •Psychological movement (perceptual dis-assembly)	THRESHOLD	•Affiliation focus •Group-quality bonding •Quality Play Visioned •Trust development •Needs reward addressment •Psychological movement (perceptions in flux) •Continuous change recognition	THRESHOLD	•Environmental resonance illumination •Risk-failure support system maturity •Individual group quality play modes established •Quality play focused & integrated •Psychological movement (perceptual shifts) •Continuous change adaptation
	PSYCHIC MASS BARRIER		PSYCHIC MASS BARRIER	

FIGURE 3

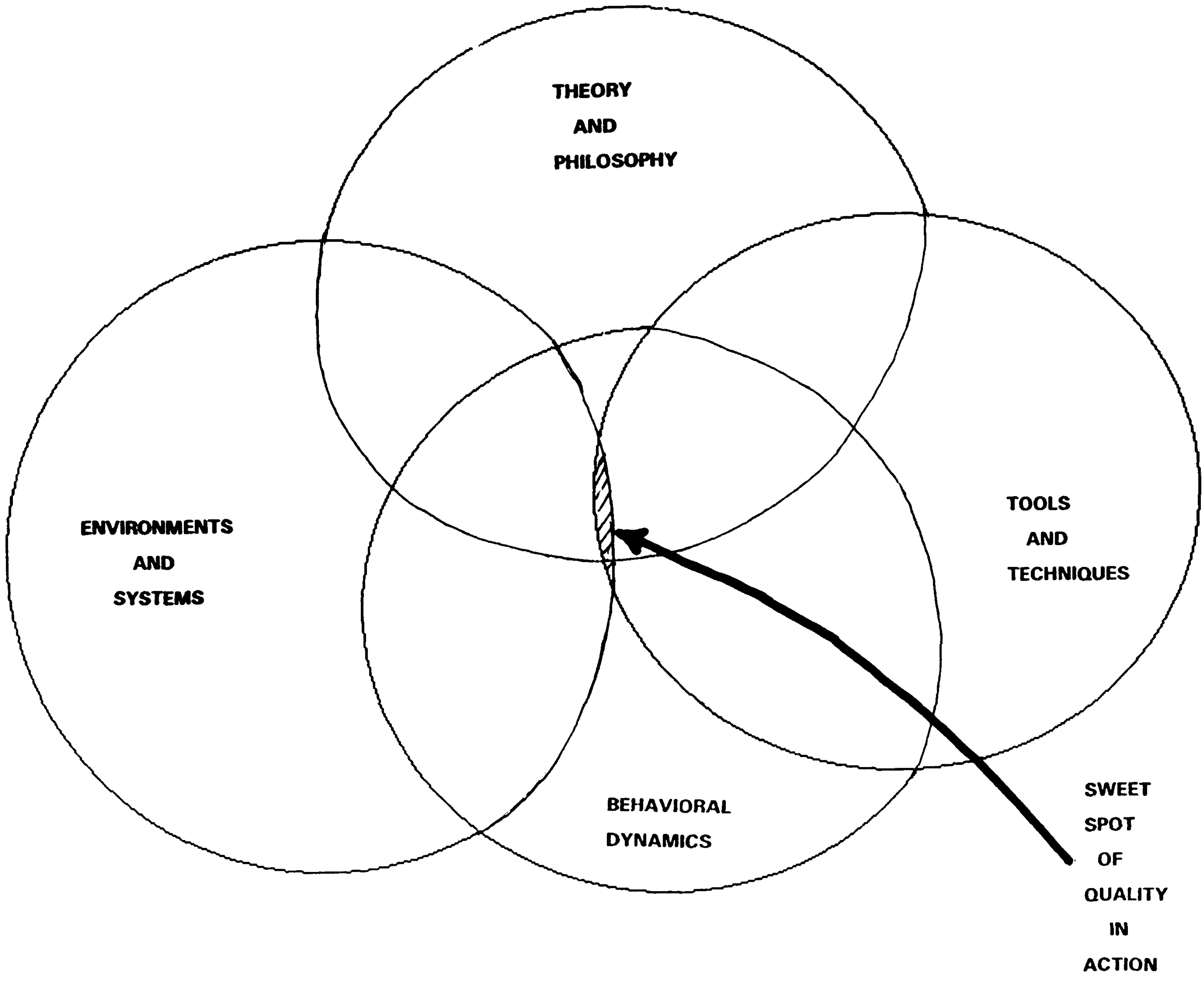

THEORY
AND
PHILOSOPHY
ENVIRONMENTS
AND
SYSTEMS
TOOLS
AND
TECHNIQUES
BEHAVIORAL
DYNAMICS
SWEET
SPOT
OF
QUALITY
IN
ACTION

FIGURE 4

1. Consider the impact of each allocation alternative on those who are affected by the choice. Seek to favor the alternative that avoids or reduces harm to the quality of the product/services and the people who enact the processes that produce the product/ services. Consider inadvertent harm possibilities in your assessment.

2. Are any of the choices unethical (i.e.- do they violate one of the ten core values?) These values are not principles of convenience, and there may be a price (short term) for the choice made. Select the alternative with no/least number of ethical violations. In your assessment of choices, remember not to overestimate the cost/risk of ethical choices nor underestimate the cost/risk of non-ethical ones.

3. Make final choices with courage, integrity, and a long term view.

- challenge all assumptions of fact, necessity and expediency (typical compromises where quality is concerned).

- picture how you (the manager/leader/quality decision maker) will be thought of in making a choice.

- long term benefits must never be underestimated; long term trumps short run.

- decision maker test.

• Golden Rule: treating others as you want to be treated?

• Publicity: O.K. to put this choice on front page of tomorrow's paper?

• Kid/wife on shoulder: O.K. to have your son/daughter/wife observe/know your choice?

• Quality Leader: Does this choice further/increase the quality of product/service?

• Quality Philosopher: This choice increases growth, development, meaning of people and their work in the organization?

SUMMARY

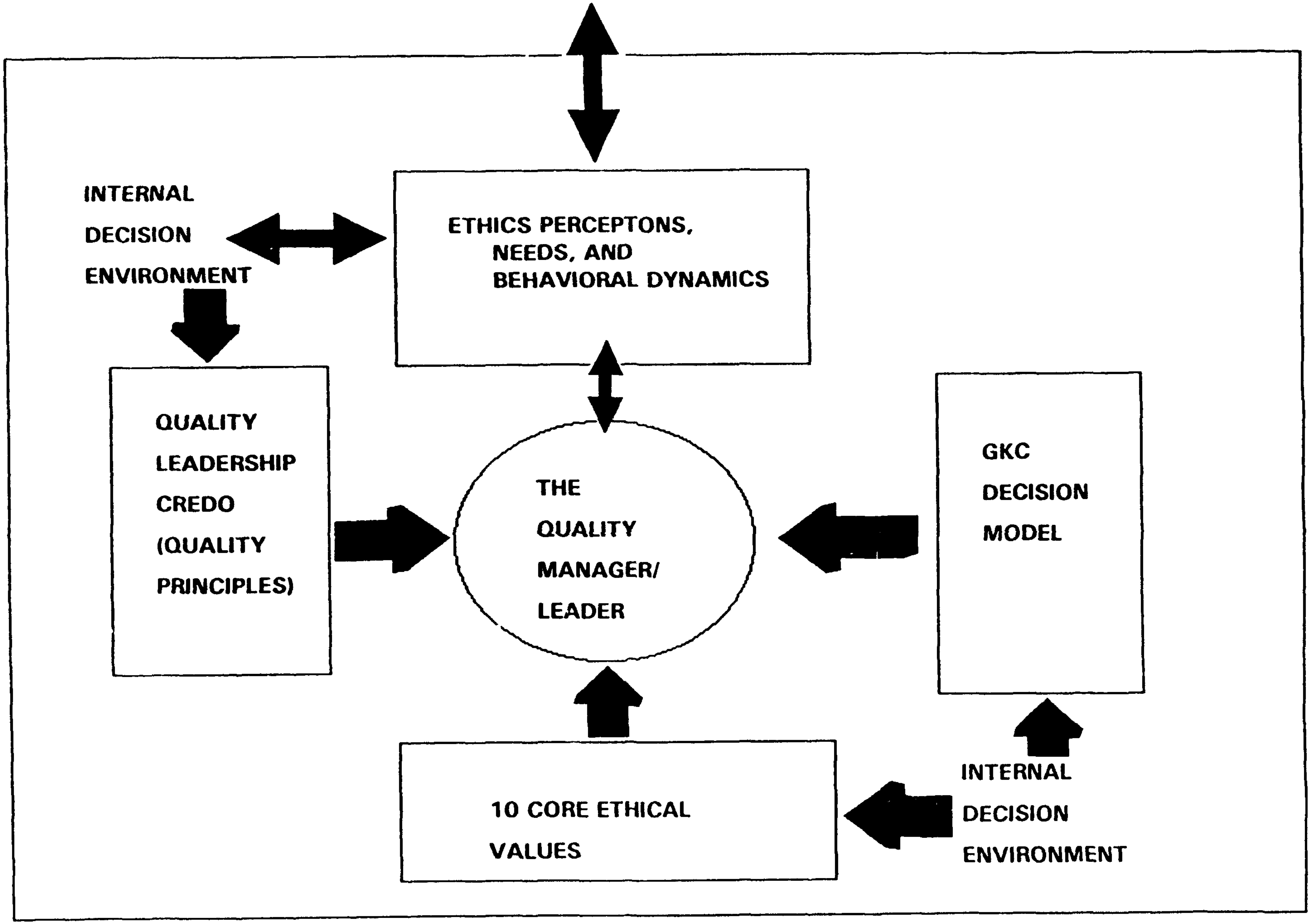
To manage ethically in modern organizations is often difficult at best. There are many barriers, and the inducements to follow the laws, rules, standards of conduct, etc., (but behave unethically in the gray areas of decision making) are legion in organizational life. The successful quality transformation of organizations demands adherence to ethical values and principles in managerial problem solving and decision making. The essence of quality ethics practice is:

R E P E A T

1. Moral Choices.
2. Conscious attention to quality values.
3. Ethical principals inform quality decisions (GKC model).
4. Ethical principals inform moment-to-moment behavior.
5. You Change.
6. Continue to refine and apply the quality ethical decision process model. (Figure 5)

If one examines the nine key concepts in the current Malcolm Baldridge National Quality Award criteria, one finds an ethical theme in <u>every</u> concept articulated by the examining board. Figure 6 refers.

The ethics of quality are, ultimately, the ethics that govern all of our choices. From our research with managers and leaders confronted with everyday quality problems and decisions, we have found that the issue of ethics is integral to nearly all the choices to be made. Sometimes the choice is obvious, but many times it is not. Where the choice is difficult, ethical dilemmas often dominate the decision environment. Frequently the choice is between the "lesser of two evils." If the choice is to further the development of organizational quality transformation, there is a preponderance of evidence from the real world of management and leadership practice to suggest that the choice <u>must</u> be one that is ethically derived. We have herein presented a model framework for that derivation.



MANAGERS QUALITY ETHICS MODEL

FIGURE 5

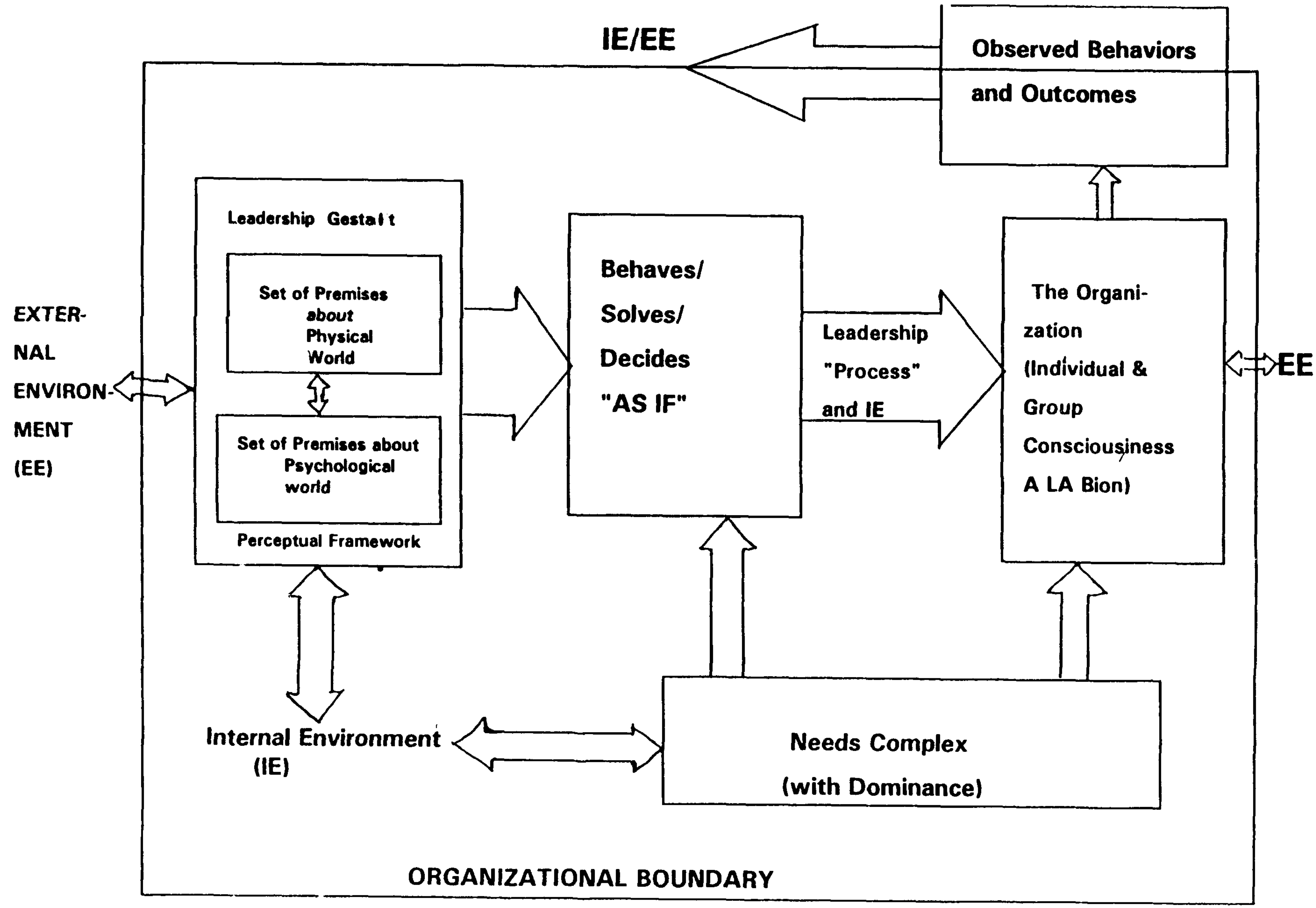

IE/EE
Observed Behaviors
and Outcomes
EXTER-
NAL
ENVIRON-
MENT
(EE)
Leadership Gestalt
Set of Premises
about
Physical
World
Set of Premises about
Psychological
world
Perceptual Framework
Behaves/
Solves/
Decides
"AS IF"
Leadership
"Process"
and IE
The Organi-
zation
(Individual &
Group
Consciousiness
A LA Bion)
EE
Internal Environment
(IE)
Needs Complex
(with Dominance)
ORGANIZATIONAL BOUNDARY

FIGURE 5

Baldridge Award Concept	ETHICAL THEME
• Quality Customer-Defined	Respect for Others Promise-Keeping
• Leadership Builds/Creates Quality Values	Responsible Citizenship Integrity; Accountability
• Quality Excellence from Well-Designed and Executed Systems/Processes	Fidelity
• Quality Goals/Strategy Planning Requisite to Success	Pursuit of Excellence Fidelity Integrity
• Operations/Process Response Time Reduction Integral to Improvement	Pursuit of Excellence Accountability
• All Employees Trained/Developed/Involved in Quality Activities	Fairness Respect for Others Caring for Others Pursuit of Excellence Honesty
• Design Quality & Defect/Error Prevention integral to Quality System	Fidelity Pursuit of Excellence Accountability
• Communicate Quality Performance to Suppliers and Partner to Elevate Supplier Quality	Respect for Others Fidelity Integrity Accountability Honesty

FIGURE 6

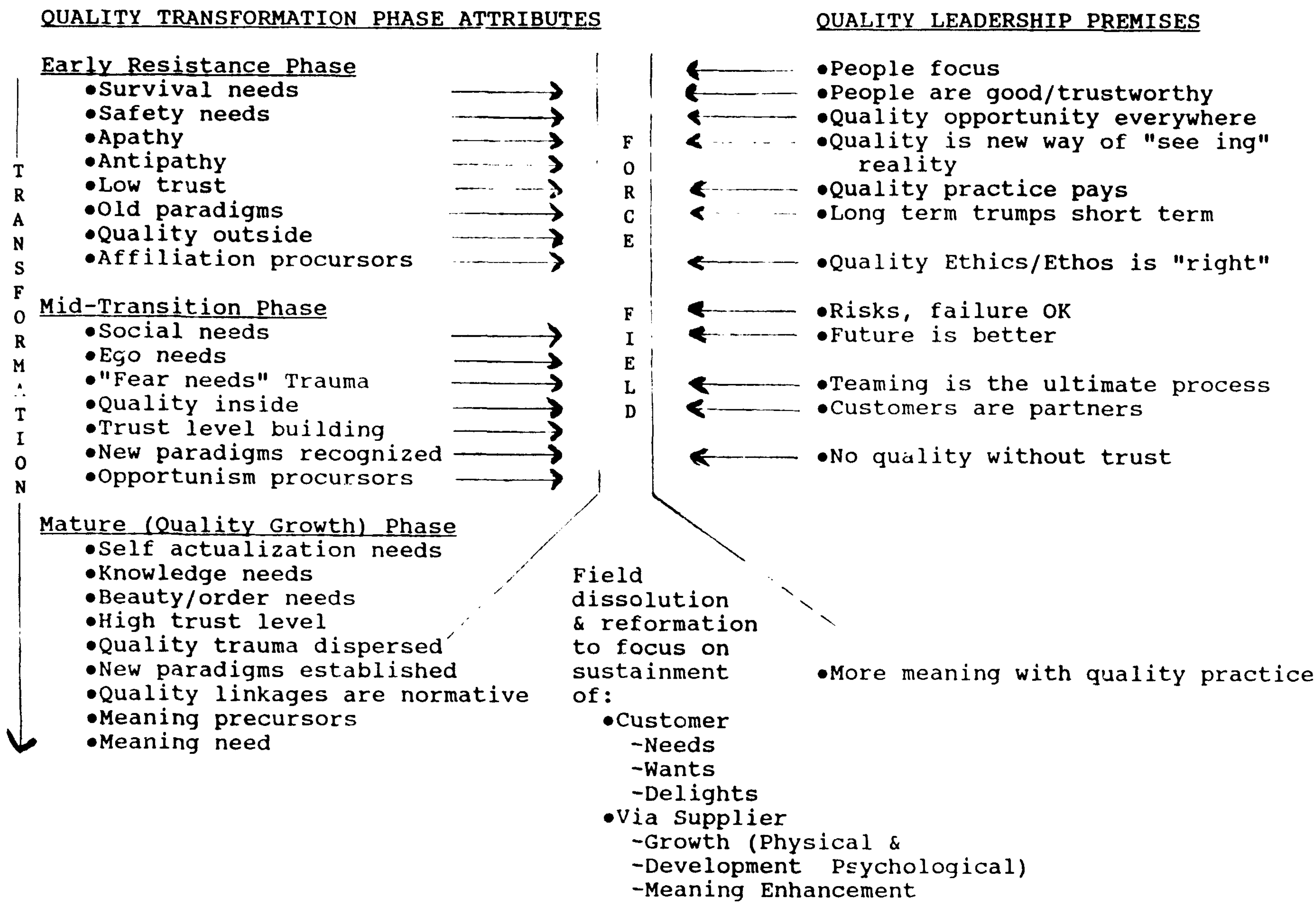

QUALITY TRANSFORMATION PHASE ATTRIBUTES
QUALITY LEADERSHIP PREMISES
Early Resistance Phase
•Survival needs
•Safety needs
•Apathy
•Antipathy
•Low trust
•Old paradigms
•Quality outside
•Affiliation procursors
Mid-Transition Phase
•Social needs
•Ego needs
•"Fear needs" Trauma
•Quality inside
•Trust level building
•New paradigms recognized
•Opportunism procursors
Mature (Quality Growth) Phase
•Self actualization needs
•Knowledge needs
•Beauty/order needs
•High trust level
•Quality trauma dispersed
•New paradigms established
•Quality linkages are normative
•Meaning precursors
•Meaning need
TRANSFORMATION
FORCE FIELD
•People focus
•People are good/trustworthy
•Quality opportunity everywhere
•Quality is new way of "see ing" reality
•Quality practice pays
•Long term trumps short term
•Quality Ethics/Ethos is "right"
•Risks, failure OK
•Future is better
•Teaming is the ultimate process
•Customers are partners
•No quality without trust
Field dissolution & reformation to focus on sustainment of:
•Customer
-Needs
-Wants
-Delights
•Via Supplier
-Growth (Physical &
-Development Psychological)
-Meaning Enhancement
•More meaning with quality practice

FIGURE 6

TOWARD A THEORY OF QUALITY LEADERSHIP

Forrest Gale, Defense Systems Management College

ABSTRACT

Out of the immense volume of material generating from both industry and government experience with organizational quality transformation, a clear picture is emerging of successful quality leadership. Both the First National Quality Conference and the recent National Symposium on Quality in Academia provided substantial insight into the behavior of successful quality leaders and the attributes of their strategies. Moreover, data collected from more than 800 DoD general officers, senior executives, and political appointees attending the DoD Executive Quality Workshops has provided corroboration for the contention that successful quality leadership practice is based upon a set of premises about the physical world and the people who make up the organization that acts in and upon this world. This paper coalesces understandings drawn from the indicated resources--as well as from recent quality literature--into a nascent theory of quality leadership. This quality leadership theory is proposed an a experiential explanation for the success of the quality ethos in a wide variety of organizational settings wherein leadership is recognized as a critically important independent variable. Cause-effect analogues are derived for a broad range of outcomes observed in organizations undergoing quality transformation.

INTRODUCTION

I have had the rare opportunity to work with hundreds of public and private sector executives over the past ten years as they have grappled with understanding the basic tenets of quality transformation, internalized them (or not), and then attempted to initiate and lead a quality transformation in their organizations. Out of the elation of success, the disappointment of failure, the puzzlement of difficulty, the shock of surprise at unexpected outcomes, and the inevitable chaos and pain of change has emerged an ever growing conviction that the general models of leadership posed and exposited in management literature do not serve as adequate benchmarks for successful quality leadership practice. These traditional leadership models are not adequate because the competencies, behaviors, and attributes they describe do not, in composite, model the leadership complex necessary for success in leading an organizational quality transformation over the long term. It is my tentative conclusion that the traditional leadership models only in part describe successful quality leaders because they do not take into account the unique environmental linkages of quality transformation. The phenomena observed are similar to those seen in the well-documented cases where a successful industry executive moves from one company to another in the same industry, only to fail in the same apparent knowledge-specific circumstance wherein he or she had previously triumphed. Traditional leadership theory explains the observed performance failure by attributing it to cultural interplay with heretofore unexposed executive weaknesses not otherwise revealed in the previous instance of success. Further, the so-called contingency and situational management theories would ascribe the observed performance decrement to the difference in the circumstances/situations of leadership. But this explanation does not reenforce the validity of such action research-derived models of leadership as the Bennis leadership strategies, where such stratagems as visioning, communication, positioning, and deployment of self were observed to have been employed in the instances of both success and failure; (i.e., a leader is a leader is a leader, in success and failure).

This paper is an articulation of the developing understanding that there seem to be some environmental uniquenesses that attend an organizational quality transformation and that--though they are not independent of cultural influences--can be seen to interact with these influences in an understandable way. Moreover, the interactions of the environment with the in-action competencies, behaviors, and attributes (leadership complex) of the leader comprise a set of observables that could lead to a developing theory of quality leadership that is compatible with and encompasses recent executive experience.

THE PSYCHOSOCIAL QUALITY TRANSFORMATION ENVIRONMENT

The environment in which a leader finds himself embedded is complex and culture-specific. Leaders have often been advised by quality theorists to "tailor" their approach to the culture of the organization. Yet, generic manifestations of a wider environmental structure remain. Out of our experience with many organizations has emerged some generic attributes of the "real" transformation environment. "Real" as used here means there is explicit external agreement among managers about the presence of the attributes cited. Figure 1 lists these attributes.

The causal elements of Figure 1 at first glance seem traditional. However, their integrated effect or lack thereof creates, along with other factors, a unique quality environment.

The functioning and influences of the environmental causal set often lead to an organization where there is a lot of language interchange but little or no ultimate quality improvement action. This is the prevalent state the author has experienced as a consultant working within many large bureaucratic organizations, some of which have been in the defense acquisition community.

The survival and safety elements of Figure 1 are associated with the lowest level of Maslow's hierarchy. As such, these needs are manifest in all organizations. But, in organizations undergoing a quality transformation they are exaggerated in importance and in frequency of domain dominance because of the strength of the change vector. Fear is bound tightly with safety and survival need in a behavioral complex which is a major barrier to quality transformation. The late Abraham Maslow, in his book "Motivation and Personality" (1956), postulated that five basic needs drove human behavior. His work initiated the formation of the human potential school of Psychology. Figure #2 shows the Maslow need model together with three superordinate levels added to the model in recent years by need theorists.

In quality transformation, it is postulated that the change vector drives the organization through a series of psychological phases in which certain needs dominate group action more than others. Figure 3 is a representation of this postulate.

An examination of Figure 3 reveals that the first phase (early resistance) corresponds to the classic "change unfreezing." In this phase, survival and safety needs dominate the psychological needs of the organization, and these needs are tightly bound to fear responses. Confusion, antipathy and apathy are widespread, trust levels are low, the organizational life is full of perceived threat and unrest (in anticipation of change/loss), old paradigms dominate, and quality is perceived as "outside" the individual. Here and there the precursors to affiliation need dominance are beginning to occur as the ethics and practice of teaming are examined. Even in so-called "high performance organizations the described need dynamics drive behavior, but the level of awareness is often (surprise) lower, and denial and reassurance that "everything is fine," we're doing well, look at our success, why change?" etc. etc. are widespread.

If a critical psychic mass (threshold) is breached, the organization flows/avalanches to the next phase of quality transformation. If the critical psychic mass (threshold) is <u>not</u> breached, the organization follows a recursive path back to the former state and begins to search for a new philosophy of practice with which to "pair." I speak of pairing here in the sense of bionic pairing, a la Wilfred Bion, a father of group behavior theory, who states that one of the classic basic assumption mental states (BAMS) of groups is idea/person pairing, the assumption colluded in by group members to avoid doing "work," where "work" is equivalent to psychic growth and development. The psychic mass (threshold) seems to be a function of some of the following:

1) The psychological maturity of the leader, and-hence-the organization

2) The reality assumptions (i.e.-what is assumed or "perceived to be so") of the organizational culture

3) The initial level of trust in the organization

4) The need levels that dominate organizational life at the time of the initiation of the quality transformation

5) The degree of leadership dispersion

6) The change orientation <u>in practice</u> of the organization

7) The extent to which personal growth and development dominate the value hierarchy of the organization

8) The level of understanding and <u>practice</u> of the teaming ethos

9) The way success is defined in the organization

10) The established internal and external environment interaction dynamics, including the communication networks and mechanisms

11) The vision of the future created by the leader, the dispersion and understanding of this vision in the organization, and its degree of inclusion of the quality ethos.

The next phase is the mid-transition phase of quality transformation. This phase is dominated by the affiliation needs (societal and ego), and corresponds to the assumptive phase of change theory. Trust levels are observed to rise, new paradigms are recognized, and quality has come to be recognized by the critical mass (organizational mentality) as "internal" to the individual. These are manifest precursors to the dominate opportunism needs of the next phase but traumatic instances of survival/safety needs occur. These instances usually accompany situational failures and personnel turbulence, and are significant because they are widely recognized for what they are. They "stand out," whereas before they did not--they were normative occurrences.

The organization at this point in the transition process (late second phase) approaches another critical psychic threshold: The quality sustainment threshold. This threshold is not well understood, but has been observed to have a level which is a function of: (1) The quality of the vision of the leader and his steadfastness of purpose in moving the organization toward it; (2) The extent of value shift towards environmental resonance and its rewards (opportunistic needs fulfillment) in the mid-transition phase; (3) The degree of attainment of entrisic and psychosocial awards (affiliation needs fulfillment) in the mid-transition phase; (4) The depth of the organizational understanding of quality and the possibility of more meaning (personal) in a sustained quality environment; (5) More deep pleasure (than before the transformation was initiated) in the organizational life and the work process (work equals "fun" for the critical mass); (6) A sense of enhanced validation of personal worth developed by the critical mass from the efforts of phase two, and specifically identified as issuing forth from the quality transformation practice as it is infused in organization principle and daily practice (i.e.-I/(we) can "see" I'm better now). Thus, what once was perceived by the group consciousness as "a way" has now become "the way".

When the threshold is breached, an avalanche of individual quality opportunism is manifested - via the learned paradigms (including teaming) of phase two--in a reaching out for individually inspired but collectively additive objectives not previously attainable. This phase is characterized, in as much as we are able to determine, by work states in which quality opportunism dominates. The world class suppliers are, for the most part, either entering this phase or well into it. The opportunistic (psychic play) needs (self actualization, beauty/order, and knowledge/need to know) are the dominate driver modes. They seem to be manifest in unique blends of loose-tight control and individualism folded (at appropriate places in the creative process) into teaming.

The high performance level of the organizations' work teams enables achievement beyond what was previously thought possible (with the former limitations of individual perceptions) but is now "expected and achieved." Team members treat each other (as customers) to Deming's "customer delight" and world class service, and teams are recognized as aggregations of customer-supplier linkages, shifting and rotating leadership (sometimes customer, sometimes supplier) as the teaming process is enacted. Teams spend a majority of their time in the Bionic state of work (structural and psychic growth and development) in the process of producing extrinsic products and services. More products/services are in the "delight" category beyond the needs-plus-wants-equal-satisfaction standards of the competitive marketplace.

Hence, this stance marks the organization as a leading edge world class quality supplier and practitioner. Trust levels are high. Quality trauma due to a high volume of risk taking (and failure-learning-growth cycling) is dispersed by normative mechanisms as it occurs. Also present are precursors to a meaning--quality need--action mode. In this mode, the ultimate expression of quality, these is widespread organizational recognition and agreement on "meaning" and an accompanying striving to increase meaning in the life of the organization. A group consciousness seems to pervade work activity that links organizational vision, mission, goals, objectives, and process enactment to (ultimately) the postulated highest order of activated need enhancement, i.e.-an increase in the survivability of the species.

This is the holy grail of quality. Thus, few (or no) organizations have achieved or sustained this Stellar quality achievement, but a number are striving to do so as awareness of the deepest meaning of quality spreads throughout the public and private sector.

QUALITY LEADERSHIP PREMISES

The Quality Ethos is comprised of four principle elements: (1) theory and philosophy; (2) tools and techniques; (3) environments and systems; and (4) behavioral dynamics. Examination of Figure 4 reveals that when all these elements are synergistically engaged, the so-called sweet sport of quality is "in action." This "sweet spot" is analygous to the spot on a baseball bat, tennis racket, etc. which--when engaged with the requisite focus--recreates exceptionally fluid performance. (see Figure 4)

Armed with understanding of the necessary synergism of these components of Deming's "System of Quality", we may still express the related experience of many quality leaders that "90% of quality achievement is behavioral." What is being said here is that, though the synergistic interaction of all the components of the quality system is necessary, the behavioral dynamics component is the most difficult to actuate and sustain. Experience with quality leaders over the past decade has led me to conclude that the behavioral dynamics of quality are experienced as more difficult to lead and manage than the other components. It is, thus, not by accident that 9 of Demings 14 points relate directly to management and leadership.

LEADERSHIP AND INDIVIDUAL TRANSFORMATION

As is widely acknowledged, the

leadership of top management is a critically important element in quality transformation. The extremely complex quality environment in which the leader interacts, however, has not been well understood, in terms of its uniqueness or implications for leadership action and behavior. Such cliches as "The leader must not only be committed but involved" (walk like you talk) abound in quality literature. But what does "committed and involved" mean? Given the complexity of the transformation process, the shifting need environments, the change dynamic, the internal and external change process drivers, etc., etc., what strategies should a quality leader follow? What are the leadership behaviors that lead to <u>long term</u> success in quality transformation?

It can be said that in an organizational quality transformation the initial transformation must take place inside the individual. Then, because most organizational processes are enacted by numbers of individuals (often in different organization functions), cross-functional teaming of individual stakeholder enactors is necessary to achieve deep knowledge (Deming) of the process and, ultimately, knowledgeable process improvement. Non-knowledgeable attempts at process improvement, in Deming's argot, are called "tampering." Once individual transformation is in process, the organizational transformation is "in process" but proceeding at a different pace. Leadership of this complex of individual and collective transformations is the challenge.

For individual transformation to progress, individual perceptions about "what is so" must change. Then, actions based on the new perceptions (tentative at first) become, ultimately, new paradigms for the organization. Working in groups, these developing perceptions coalesce to become the new organizational paradigms and eventually shape the new quality culture. Moving from one phase of quality transformation to another is thus a psychological journey in which needs and perceptions interact in and with a complex environment to drive behavior.

Since we are unable to change the basic stuff of humanity (i.e., the needs come with the organism), we must attempt to understand how the needs and the environment interact through perception. Then, leaders can work to create and interpret environments that possess perceptual analogs with a high probability of interacting with known need dominances to produce quality behavioral shifts. These shifts, the paradigmic shifts of the literature, ultimately result--in group interaction--in the quality culture shifts of the organization - the desired quality transformation.

Figure 5 is a representation of this environment - need -

perception quality leadership concept.

ATTRIBUTES OF THE SUCCESSFUL QUALITY LEADER

What are the premises that appear to be held and behaviorally honored by successful quality leaders? What are the skills a successful quality leader seems to practice? Based upon interviews and small group experiences with hundreds of successful quality leaders, the following answers are emerging:

- Has a well-developed sense of timing.

- Can visualize a future not logically derived from either the past or the present.

- Is inordinately persistent/patient (has inner strength); maintains an apparently relentless focus on what could or should be (the vision).

- Possesses a genuine, deeply felt affection for the human condition, for others (and--hence--for self).

- Possesses a positive (hopeful) outlook on the future and its possibilities.

- Is a skilled communicator, verbally and non-verbally; appreciates and can express the subtleties and nuances of experience and culture with force and clarity.

- Holds a manifest feeling that overt actions can lead over time to permanent changes in outcomes (a feeling of being in control, rather than helpless).

- Has an abiding curiosity about quality, leading to a continuing search for deeper understanding and a coming to terms with what it is and is not.

- Evidences a high tolerance for short term failure; shows an obvious hunger to learn, coupled with the apparent recognition that more is learned from failure than success.

- As a risk taker--seems willing to continually take personal and organizational risks (self recognized) in order to cause/allow organizational and personal growth and development to take place.

- Has a polished understanding of and comfort with group/team dynamics; this is often manifested by constant practice of teaming with groups to solve problems/make decisions.

- Possesses a high tolerance for ambiguity and uncertainty (low demonstrated anxiety level); is an incremental group problem solver on complex issues; satisfices and muddles through.

- Values human differences, including opinions and approaches; but balances this with apparent understanding of where deviation leads to quality, and where it does not.

•Sees or is beginning to see human behavior as a flow of extremely complex processes; process thinking dominates his/her communication, and thus becomes the normative mode of interaction and anecdote.

• Holds an ethic in which the measures of self worth and value added are embodied in "knowledgeable customer" satisfaction.

• Consistently behaves with a service orientation - an observable desire to serve both employees and output-linked (external) customers.

• Has a long term view; is less interested in short term results absent analysis of the long term implications.

• Is a very active networker; continually maintains and grows a network of human interaction both inside and outside the organization.

• Spends widely observed time working on quality improvement strategies; not only talks about quality but is seen working in groups on quality issues.

• Has articulated and baselined an agreement with both external customers and employees on what quality (currently) is, and is visibly assessing both achievement and improvement.

• Seems to be an excellent judge of people-their knowledge, skills, abilities, behavior, communications; can assess human strengths and weaknesses and can match the talent to the job; skilled at forming effective interdisciplinary teams.

• Can and does trust others; willing to significantly delegate, and has the faculty to trust others in the face of complexity, difficulty, and ambiguity; believes they will "come through with quality" even though he/she is occasionally disappointed; aims high and expects high quality performance which is carefully and clearly articulated.

• Is ethical; possesses an ethical decision making model and uses it; seems not afraid to go against the majority opinion or high authority if ethics are the issue.

• Courageous; will pursue quality even though the odds are unfavorable if growth and development of individuals/the organization is at stake.

• Defends his people in public forum against inappropriate/ unfair attack; handles matters of ego, disappointment, and possible malpractice privately and face-to-face.

• Restless; always reaching for something better for the organization and its individual constituents.

• Opportunistic-perceives opportunity (the glass is always half full, not half empty) in quality and reacts quickly to perceived favorable circumstances.

- A terrific listener-listens with eye and mind as well as ear; listens non-verbally, and asks questions structured to grow and develop the sender.

- Has a sense of humor, fun, and perspective - finds the human condition amusing; considers work, within the apprehension of the full range of human behavior, as fun.

QUALITY PREMISES--A DEVELOPING MODEL

While we can say that not all quality leaders possess the perceptions or manifest the behaviors outlined above, we can propose that the litany of observations outlined above forms the basis for a possible model of the premises upon which successful quality leadership behavior is apparently based. Some of these premises appear to be as follows:

- People and behavior are the central focus of quality action; all else will follow.

- People are intrinsically good and trustworthy, and motivated appropriately will do their best.

- Quality opportunity is everywhere.

- The quality ethos is a new way of perceiving reality.

- Quality practice pays off.

- Long term outcomes are more important than short term outcomes.

- The world is risky, uncertain; taking chances is part of being alive. Failure is okay.

- The future can be better, and I can make a difference.

- The teaming process is the only feasible way to attack complex problems.

- Customers are partners.

- There can be no quality without trust.

SUMMARY

As the premises upon which successful quality leaders base their actions result in quality improvement, they are reenforced and apparently become components of the perceptual framework of others in the transforming organization. Though the leadership model is incomplete, the picture of the quality leader is becoming clearer. We can match the leader's premises (which guide his perceptions) with the dominant needs of the various quality transformation phases and thus achieve a sort of mapping of the dynamics of quality leadership. In the illustration shown below (Figure 6) we can see the leaders "premises" in action, as he/she works to deal with needs and environmental factors to achieve the critical mass necessary to breach the interphase quality transformation barriers. In this sense, the successful quality leader is like a grand strategist, utilizing the components of quality in an orchestrated behavioral flow. What makes the result unique is that, though the orchestral baton may cease its constant flight, the orchestra will play on, observing the timing and muse of the vision and process of the leader. Thus can we hope to speak, ultimately, of the quality consciousness of an organization in which an organization _is_ quality, an embodiment of its response to its perceptions, needs, environment and leadership.

IMPLEMENTATION OF SELF-DIRECTING WORK TEAMS IN A DOD PURCHASING SECTION

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ABSTRACT

As chief of one of the purchasing sections at the Oklahoma City Air Logistics Center, the author received approval from the Directorate of Contracting and Manufacturing in January 1990 to conduct a special project in the implementation of total quality management (TQM). The project entailed organization of section personnel into two self-directing work teams (SDWTs) to conduct daily operations exclusively within the TQM framework.

As the name suggests, a SDWT is a group of employees working together on a day-to-day basis with increased workload management responsibilities. Such teams are designed to achieve the twin TQM objectives of maximum customer satisfaction and continuous process improvement. The two teams formed in the section each have 6-8 members, a mix of contracting officers, buyers and a clerk. Leadership of each team rotates among its members. Both teams hold regular weekly meetings and report on their progress at monthly section meetings.

Implementation took place in the following three phases:

Phase I: Team Building

Training: TQM fundamentals and teamwork.

Action: Writing team operations manual.

Phase II: Process Analysis

Training: Statistical process control.

Action: Flow-charting the process.

Phase III: Customer Orientation

Training: Quality function deployment.

Action: Beginning of control charting.

At the time of this writing (December 1990), the project has been under way for eleven months and has already yielded a number of benefits. The team framework fosters cooperation and consistency in decision-making, ready identification and solution of mutual problems, and flexibility in workload management. Team members are asking hard questions about the way we do business, and are gaining a greater understanding of their collective mission. According to various indicators quality and productivity are both improving.

The project is demonstrating that SDWTs can be established within a traditional organizational structure, to yield all the benefits promised by TQM. A minimum of time and resource expenditure is required to achieve this, and the teams can be established without changing existing personnel regulations or procedures.

The paper emphasizes the practical aspects of the project as a useful model for localized TQM implementation.

INTRODUCTION

By now, most of us who work for the federal government are probably familiar with the concept of total quality management (TQM). We understand that we must listen to our customers in order to assess the effectiveness of our operations, that we must continuously improve the efficiency of our operations in order to remain competitive, and that we must rely on teamwork as our fundamental operating principle.

Yet despite our growing familiarity with TQM--or perhaps because of it--most of us are asking some very basic questions: Is TQM simply a fine-sounding philosophy, or does it have a practical application? If it does have a practical application, what is it and how should we implement it? Will it work as well if we implement it locally, or must we transform the entire agency first?

This paper describes a special project in TQM implementation designed to answer these questions. The project was implemented in a purchasing section of the Oklahoma City Air Logistics Center (OC-ALC) by the author, who is chief of that section. It was designed to be as practical as possible. No attempt was made to change the outside organizational structure or existing personnel regulations.

BACKGROUND

The Section. The WWABNCP Contracting Section (LADCC) provides contractual mission support for the Worldwide Airborne Command Post (WWABNCP) fleet of EC-135 and E-4B aircraft, as well as for the purchase of -135 spare parts. This includes modification and maintenance support such as the PACER LINK modification block contracts and the specialized engineering services contracts to support the WWABNCP programs. In terms of number of purchase requests (PRs) currently in process, approximately 85 percent of the workload is spare parts and 15 percent is programs; in terms of dollar value, the percentages are, roughly, reversed. This workload is currently being handled by three GS-12 contracting officers, three GS-11 contracting officers, four GS-9 contract negotiators (buyers), two captains (also buyers), and two GS-5 clerks. The current staffing and workload of the section are slightly different now from what they were at the start of the project in January 1990, but the changes did not affect implementation of it.

Prior to inception of the project, the section and mission support were both structured along hierarchical lines: Contracting officers handled the program acquisitions, and the buyers handled the spare parts purchases. Each contracting officer specialized in just one part of the program. The section chief assigned workload and reassigned it as circumstances warranted. All personnel worked basically on their own. When problems arose or questions needed to be answered, a buyer or contracting officer would consult a designated contracting officer at the next higher grade or the section chief.

TQM. If we are to understand the practical application of TQM in general, and the impact it has had on the section in particular, we must begin with a brief look at basic TQM theory. We are by now all familiar with the "14 Points" of the philosophy of W. Edwards Deming, the "Ten Step Plan" of Joseph Juran, and the "14 Steps" of Philip Crosby.(1) These authors and a growing number of other writers have contributed to our understanding of TQM. But in the last analysis, if we search for the basic themes, the underlying elements common to all the philosophies, we find that TQM is nothing more than a systems approach to management and operations. It consists basically of just three components, as shown in Table 1 below:

Table 1: TQM Components

Customer Orientation
Process Improvement
Teamwork

First, we must take as our highest priority our customers' requirements and expectations, if we are to be sure that the outputs of our system are useable or sellable. Second, because we live in an environment of constant change, we must continually improve our own system and the processes within it, if we are to remain efficient in meeting customer requirements and expectations. Third, we must organize our operations to assure the smoothest lateral flow of material and information through the individual processes. This is best done through the use of a team structure which allows the people who are most directly involved in each process to take control of it, focussing their energies and talents on continuing analysis and innovation through cooperation.

The basic ingredient in a practical application of TQM is therefore the change in the structure and working methods of daily operations brought about by management conversion to the systems/TQM approach. Table 2 summarizes the components of this change.

Table 2
Traditional vs. TQM Organization

	Tradition:	TQM
Focus of responsibility	Individual, task	Team, process
Workload mgt.	Supervisor	Team
Process improvement	Managers/ specialists	Team
Results	Control, rigidity	Cooperation, flexibility.

The focus of responsibility shifts from the individual with an assigned set of tasks to the team with control over the entire process. Success in operations is therefore measured in terms of the team's effectiveness in meeting customer needs, rather than the individual's ability to accomplish the tasks dictated by the job itself. Upper management retains control of the entire system, but directs its efforts to the needs of the teams; teams take responsibility for management of their workload and improvement of the process. The result will be an organization structured for maximum flexibility in meeting change, based on cooperation between all personnel involved in it.

Using industry as a model, we find that practical application of TQM requires the establishment of three types of teams. These types are shown in the "Purpose" column of Table 3 below. The first team to be established is typically the upper-level management team tasked with implementation of TQM throughout the system. The management team forms teams of employees involved with individual processes needing correction, tasks the teams with providing a plan to make the correction, then disbands each team as it completes its assignment. Finally, the entire work force is organized into teams to conduct the company's day-to-day operations on a TQM basis.

When the SDWT project began, the contracting organization within the Air Force Logistics Command (AFLC) had already firmly established its TQM initiative entitled "Total Quality Contracting" (TQC).

Table 3: TQM/TQC Teams

Purpose	Team
Implementation	Steering Committee /Quality Council
Process correction	Process Action Team
Daily operations	Self-Directing Work Team

The Directorate of Contracting and Manufacturing (PM--now the Directorate of Contracting) at OC-ALC and the other Air Logistic Centers had established the first two types of teams: an Executive Steering Committee/Quality Council was in place at each Center, and numerous process action teams (PATs) were working on various parts of the acquisition process. Employees were well versed in the TQC philosophy, and the PATs were beginning to make recommendations for improvement of daily operations. The time was right to take the final step, and create the teams which would handle daily operations within the TQM framework.

The Self-Directing Work Team. The author attended the "Federal Quality and Productivity" seminar (FQPI - to be renamed "Total Quality Management in the Public Sector" in FY91) given by the Office of Personnel Management (OPM) in Denver CO in November 1989. This seminar focussed on various TQM initiatives in both the public and private sectors, specifically the structure and use of teams in daily operations. What follows are the critical concepts presented in that seminar, used by the author to establish his own teams.

The use of daily operations teams as part of a TQM implementation program was already becoming increasingly prevalent in the American private sector. At one end of the spectrum, for example, is the Florida Power and Light Company, which made a deliberate, company-wide effort to implement TQM and the teams which go with it--and became the first American firm to win a Deming Prize as the result. At the other extreme are organizations such as the Accounting Department at Colorado State University (CSU), which implemented daily operations teams as a kind of grass roots effort, without having the University adopt TQM first. The obvious conclusion to be reached from these and similar experiences is that the team approach can be tailored to the circumstances at hand.

By contrast, the agencies of the federal government offered far fewer examples of the use of teams for daily operations. Consider the 1989 Quality Improvement Prototypes listed in Table 4 below:

Table 4
1989 Quality Improvement Prototypes

DoD:	Naval Publications and Forms Center
	Norfolk Naval Shipyard
IRS:	Fresno Service Center
NASA:	Lewis Research Center
VA:	Kansas City Medical Center

These agencies had all begun to implement TQM with positive results, but none had as yet established daily operations. In other words, their TQM programs were all at approximately the same stage of development as was the AFLC's.

Two Department of Defense (DoD) organizations, however, had adopted a total team approach. These are the Directorate of Distribution at the Sacramento Air Logistics Center (Project PACER SHARE) and the Defense Logistic Agency's Defense Depot Ogden UT (DDOU). Their endeavors began with obtaining Congressional approval to change personnel regulations to adopt gainsharing, pay-banding, and appraisal of the team rather than the individual. Typically, the first-level supervisor became the permanent team leader, with the result that the team replaced the section or unit as the basic component in the organizational hierarchy.

In summary, the author reached the following conclusion: It does not matter whether one considers the private or the public sector, whether TQM is implemented on an organization wide basis or not, whether the organizational framework has been changed or not, all teams established to handle daily operations share the same basic characteristics. The clearest description of these characteristics available to the author at the time of implementation in LADCC was that of DDOU. This description was presented at the FQPI seminar by Carlo J. Stallo, Program Manager for the project at DLA, and can also be found in Vol. 54, No. 64 of the Federal Register dated 5 April 1989.(2)

DDOU called its operations teams "self-directing work teams" (SDWTs), and defined a SDWT as "a group of employees who take responsibility for a whole process that delivers a product or service to an internal or external customer. SDWT [members] work together to take corrective action on day-to-day problems and are involved in planning, controlling, and improving their operations."

According to DDOU, redesign of the organization to make the transition to the team concept requires management to take the steps shown in Table 5:

Table 5: Redesign Steps

1. Organize around the whole process.
2. Increase internal flexibility to do the job.
3. Remove the separation of planning, control and improvement functions. Empower employees in the teams to do these functions.
4. Redesign information systems so that information flows to the point of work.
5. Create structures, processes, and skills that enable employees to use information for decision-making, self-correction, and on-going improvement.

Also according to DDOU, once the transition has been made, and SDWTs become the fundamental means of conducting the organization's business, the benefits listed in Table 6 below will likely be realized.

Table 6: Potential Benefits

1. Better understanding of the organization's mission.
2. Greater trust and cooperation.
3. More responsibility taken by employees for doing the job well.
4. Better communications: Fewer filters provide clearer problem definitions and solutions.
5. Customer needs understood better and met faster.
6. Higher quality.
7. Higher productivity.

IMPLEMENTATION

The title "self-directing work team" and the basic model were adapted from the DDOU project for implementation in LADCC, but with several critical differences, as shown in Table 7. Since the purpose of the LADCC project was to determine whether such teams could be established on a localized basis with a minimum of disruption of the existing organizational structure, no attempt was made to change any of the existing personnel regulations. Neither gainsharing, pay-banding nor team appraisals were established; existing position descriptions and performance plans remained in effect. No attempt was made to draw team members from outside the section. No changes were made to existing information systems; computer products provided to the section chief were simply made available to the teams. And leadership of the LADCC teams rotates among team members. In other words, implementation amounted to a self-help project, as a demonstration of the practical applications of TQM in general and the flexibility of the team concept specifically.

Table 7
LADCC vs. DDOU Teams

Feature	DDOU	LADCC
Implementation	Depot-wide	One section
Environment	Production	Administration
Membership	Multi-skill	Purchasing
Leadership	Supervisor	Team member
Compensation	Pay-banding Gainsharing	GS Schedule
Appraisal	Team	Individual

The total project was implemented in three phases, corresponding to the three components of TQM mentioned above (teamwork, process improvement, and customer orientation), with the second and third phases adding additional dimensions to team operations. The author personally conducted all aspects of the implementation, including training, on the basis of his experience at the FQPI seminar. Following is a brief description of each implementation phase:

Phase I: Team Building. The author received approval from PM in January 1990 to begin the project. The project was described to personnel in LADCC with the focus to be on the spares acquisition process. Membership on a team was voluntary, and in fact one GS-12 and GS-11 contracting officer elected not to join teams initially, because their workloads did not involve spares buying; they have now become members of a team after the teams made the transition to program buying discussed under Phase II below. Two teams were formed in the section to allow for maximum diversity of approach and optimal team size. Each team had six or seven members, and each comprised contracting officers, buyers and a clerk. Personnel were assigned to teams on the basis of personal preference. All team business was to be conducted democratically, with each team member having an equal one vote.

The project began on 4 January 1990 with the first of three 2-hour training sessions on the fundamentals of TQM and the use of such group decision-making techniques as structured brainstorming and nominal group technique. Each training session ended with the teams working on their own with some example requiring a teambuilding skill. The teams were tasked with writing operations manuals containing a mission statement and descriptions of how they would manage their workload and conduct team business. The purpose was basically to make sure that team members gave serious thought to team operations and to provide a benchmark for continuous improvement of the team process. Both teams began meeting on a weekly basis, and both completed their manuals by the end of March.

Phase II: Process Analysis. The teams became fully operational on 22 March 1990. This meant, first of all, that the teams--not the section chief--were now responsible for distributing and redistributing as necessary the spares workload of the section, the first critical step in changing the focus of responsibility for the process. Second, the teams were introduced to the basic techniques of statistical process control, and were tasked with completing a top level flow chart of the spares acquisition process as the starting point for continuous process improvement. Regular monthly meetings of the entire section were established to discuss team progress. Third, the process of problem-identification, -solution and follow-up was formalized. Problems identified by team members or the section chief would be brought to the attention of one of the teams. The team would then analyze the problem to determine if the team or the section chief could solve it. If not, it would be forwarded to the Quality Council for resolution by a PAT. If the team found a solution, the problem and solution would be presented by a team member at the monthly section meeting. This practice served to provide refresher training in areas which created problems or inefficiencies in the system. Finally, because of an increasing workload of program acquisition actions, both teams began to transition from a focus purely on spares buying to one that included program buying as well. This meant that all buying personnel, regardless of grade, shared program workload responsibilities. At the end of this phase, virtually all buyers and contracting officers were handling program buys.

Phase III: Customer Orientation. The final implementation phase began in July 1990 with training in quality function deployment (QFD), a systematic approach to collecting customer data and using a mathematical matrix to define process improvement needs. Customer orientation is approached as a three-step process: customer identification; customer survey; use of customer survey data to determine what to measure and improve. As of this writing, the teams are beginning to take the three steps informally; later they will repeat the process on a formal basis.

Teams are determining which customer representatives to invite to team meetings and what questions to ask regarding our own ability to meet customer requirements and expectations. As part of this preparatory step, a special arrangement has been made with the item management organization for purposes of gaining greater familiarity with the process before the customer survey is taken. Each week an item manager visits a buyer, and a buyer visits an item manager to learn first-hand each step in the other's process. A similar arrangement will be made later with the program management organizations and other customers. The teams will then establish control charts to measure those quality factors determined by customer response to be most important. When the control charts are established, the teams will begin again, issuing a written customer survey and determining which areas of the process need greatest improvement, using a QFD matrix.(3)

RESULTS

Although implementation of the SDWT project has been in process for less than a year, a number of positive results have been generated. These may be described as follow:

Improved Operations. The author conducted an opinion survey of team members at the end of June 1990. At that time the quality and productivity indicators demonstrated that the project was successful from a management standpoint. The purpose of the survey was to determine what was working well and what needed improvement from the team members' standpoint. The survey was divided into three parts: a set of ten questions on how the team project had enhanced the quality of individual work life; a set of ten questions on how well the project was implemented; and a set of three questions on the project in general. Results of the survey indicated that team members noted improvement in four areas:

1. Ability to get things done quickly. One respondee noted that, "Improved communication provided better understanding, and processes moved faster."

2. Familiarity with new policies and procedures. One respondee commented, "All changes in policy and/or procedure are discussed in great length at our team meetings."

3. Understanding their role in the mission of the section.

4. Quality of everyday life. One of the first suggestions for improvement made by the teams was rearrangement of parts of the work area. This was done shortly after the suggestion was submitted. One respondee cited this as an improvement in worklife, but also noted that the teams "feel more in charge of our destiny."

The general questions in the third part of the survey generated basically two clusters of comments centering on the value of the team structure in handling the workloads of absentee personnel, and the value of shared responsibility for workload management in general.

Two additional improvements can be cited on the basis of observation only, but they are significant in terms of process efficiency:

1. Cooperation and sharing of mutual problems and solutions has led to increased consistency in operations. The team structure and atmosphere have given all participants a more conducive forum for airing problems and seeking mutually agreeable solutions. This process is probably the reason for the first three of the four favorable responses to the survey questions discussed above.

2. Formalization of the problem-identification, -solution, and follow-up has also yielded tangible benefits in the area of quality improvements, as discussed below. Presentations made by team members on topics of general interest were in fact considered to be the most valuable part of the implementation of the project.

In summary, these results indicate that at least the first four of the potential benefits listed in Table 6 above are being realized.

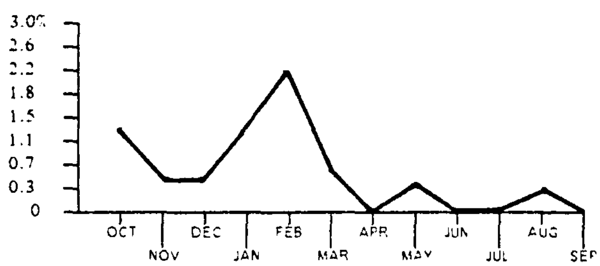
Better Quality. The Directorate measures quality in terms of error trends in five areas of the acquisition process. The author monitored the progress of the section throughout SDWT implementation using the two indicators which are, in his opinion, the most comprehensive and reliable. These two are explained below, and the run charts for LADCC in FY 1990 are presented and discussed immediately after the explanation.

1. E841 Error Rate. The percentage of errors committed per element when buyers complete the "Frequency Analysis Input Form," AFLC Form 41. This

form must be completed and submitted with each contracting action--basic contractual document, modification, order--including PR cancellation. The data on the form is used to calculate the number of hours earned by the section for the types of documents it processes. The section's record for FY 1990 is shown in Figure 1 below.

Figure 1 is perhaps the clearest indication that the team process improvement program is working. The author identified the rising error trend to all employees in March 1990, after the extremely high error rate for February became available.

Figure 1: E841 Error Rate



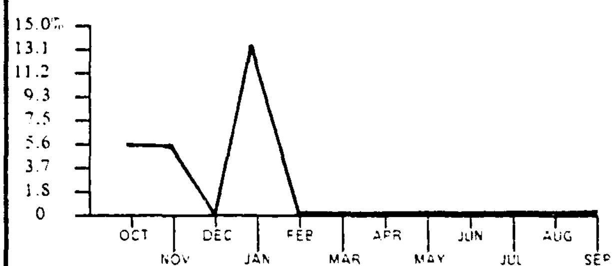
ERRORS	10	2	2	7	10	2	0	1	0	0	1	0
ATTRIBUTES	775	492	457	561	459	339	393	297	243	410	374	324
% ERRORS	1.29	40	44	1.25	2.19	59	0	34	0	0	27	0

In April, a presentation was given by a team member to all section employees on how to correctly code AFLC Form 41. The number of errors for that month dropped to zero, and the highest number of errors in subsequent months was one. (In October, not shown in this figure, the number of errors was one, and the percentage was .29 of the base of 340 attributes.)

2. DD350 Error Rate. The percentage of errors committed per document in completing the "Individual Contracting Action Report," DD Form 350. This quality indicator is slightly less comprehensive than the E841 Error Rate, because the DD350 must be submitted for completed contract actions over $25,000 only. The section's performance in FY 1990 is shown in Figure 2. No additional discussion is needed, as a glance at the chart will make the conclusion self-evident. The section appears to have stabilized this process as well.

Higher Productivity. All PRs entering the procurement process are listed and tracked by an automated system. This system weekly prints a list of all PRs assigned to each buyer and a number of summaries and tabulations for use by supervisors. These documents are designed to provide visibility primarily in the areas of timeliness and productivity. All supervisors are required to keep run charts on "PR Processing" for their sections, showing the

Figure 2: DD350 Error Rate

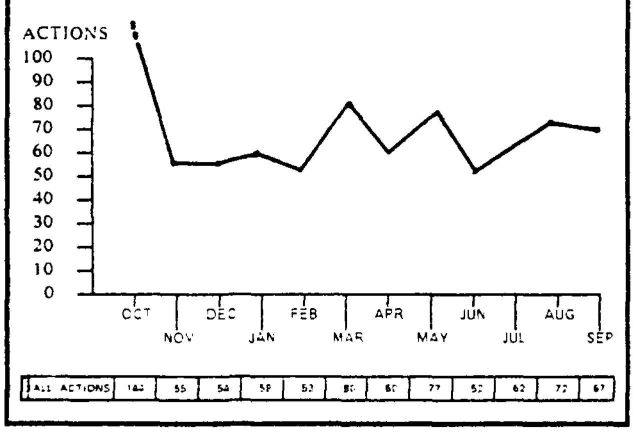


ERRORS	1	1	0	2	0	0	0	0	0	0	0	0
DOCUMENTS	18	19	3	15	10	12	13	11	3	14	14	46
% ERRORS	5.6	5.3	0	13.3	0	0	0	0	0	0	0	0

average number of days over or under the aggregate cycle time standard in which the PRs in their section were converted into contractual documents. The FY 1990 chart for LADCC appears as Figure 5 below, the last of the three charts on productivity. Before we examine it, however, we can look at two simpler summaries of the section's performance.

1. Productivity. Figure 3 below shows the total number of PRs the section converted into contractual documents each month in FY 1990, the simplest measure of productivity.

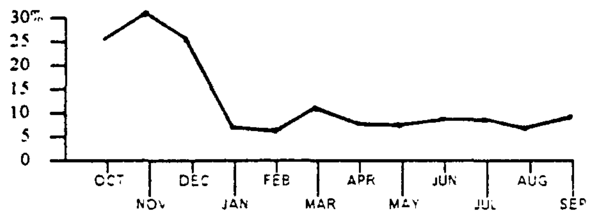
Figure 3: Productivity



In evaluating Figure 3, we must understand that the data point for October 1989 is artificially high, since it contains actions completed in September 1989 but not released because of funding constraints. The totals for the following months show the impact which implementation of the SDWTs in January 1990 has had on productivity, particularly after the teams became operational in March. The average number of documents completed in July through September 1990 is about 23 percent higher than the average for November and December 1989. A simple straight-line calculation for the data points from November 1989 through September 1990 yields an upward productivity rate of about 2 percent. (The productivity trend established in FY 1990 has continued into FY 1991. The totals for October and November 1990, not shown on this chart, were respectively 83--the highest since the team project began--and 69.)

2. In-Process Delinquencies. Figure 4 shows the number of PRs remaining delinquent in terms of cycle standards at the end of each month as a percentage of all actions in process. The steep decline from December 1989 to January 1990 resulted from the restart of all stock-funded (spare parts) PR cycles, and must therefore be ignored as a variable beyond the control of contracting personnel. The important observation here, obviously, is the almost complete stability of the process beginning in March 1990. Logic would tell us that, following the January decline, the delinquency rate should have moved up again, if all other variables were relatively fixed (as in fact they were). This did not happen. On the contrary, the number of PRs remaining delinquent at the end of each month plateaued at between 14 and 19, and the percentage between about 6 and 9, indicating that the process had stabilized. (In October 1990, which is not shown on this chart, the number climbed sharply to 43 and the percentage to about 24, but this variation is assignable: Most of the section was working on program PRs at the end of the fiscal year and neglecting the spares PRs, which steadily became more delinquent. At the end of November 1990, the number had fallen to 34 and the percentage to about 20.)

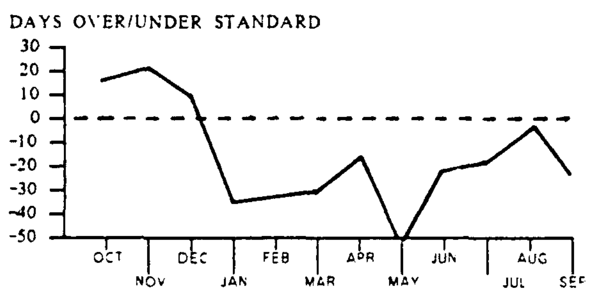
Figure 4
In-Process Delinquency Rate



DELINQ PRS	54	55	48	12	10	21	17	17	16	20	14	19
ALL ACTIONS	213	193	168	188	184	198	215	221	207	234	239	210
% DELINQ	25.4	31.1	25.5	6.4	5.4	10.6	7.9	7.7	8.7	8.5	5.9	9.0

3. PR Processing Time. Figure 5 indicates that in every month of the fiscal year, beginning in January 1990 (after the restart of the spares cycle times described above), the section has awarded its contractual documents in considerably less time than the standard. In fact, the section's record has been better than that of the Directorate as a whole in every one of those months except August 1990. In October 1990 (not shown on the chart) the average was 14 days below standard, again better than the Directorate average.

Figure 5
PR Processing Summary



ACTIONS (PR)	126	55	39	45	37	68	45	38	39	75	48	31
ACTION DAYS	89	103	79	48	43	53	63	57	60	71	82	82
STD DAYS	74	82	71	83	75	82	80	104	83	90	86	107
DIFF (DAYS)	15	21	8	-35	-32	-29	-17	-52	-23	-19	-4	-25

Challenges. Implementation of self-directing work teams requires a nearly total reversal of the traditional ways of doing business. The change to the new way of thinking and working was not an easy change to make, particularly since the project was implemented within the confines of a traditional organization. The most important challenges facing the author and section in making the transition may be described as follows:

1. The element of time was a critical factor in many aspects of the project. According to the results of the team member survey, the element of time--time for training, time to plan and attend team meetings and time to continue with the usual tasks of the acquisition process--was a matter of general concern. It must simply be understood that, for a project of this magnitude, a significant investment of time is required in the beginning on the part of all participants, and the project must be given time to mature before tangible results can be expected.

2. The role of the clerk as a team participant could not be established with certainty. From the standpoint of TQM and team theory, the clerk should share all team responsibilities on an equal footing with other team members. But, practically speaking, we might not consider it fair to ask a clerk to share team leadership responsibilities involving workload distribution.

To give a complete picture of the project, however, it must be noted that some features which might have been expected to create problems did not. First, the section was able to manage its regular workload, even increase its quality and productivity levels, while handling all the additional tasks associated with implementing the team structure. Second, the democratic structure and rotation of leadership of the teams appear to have been accepted without problem by the higher-grade personnel on the teams. Finally, the fact that some people in the section did not initially participate on a team does not appear to have been a matter of concern to other members of the section. The flexibility of the team structure, in this author's opinion at least, was the principal reason.

CONCLUSION

To recapitulate, the SDWT project has been under way for eleven months, and the teams have been operational for all but three of those months. Implementation is still not complete, but evidence indicating that the project is a success is both abundant and compelling. In summary, we can offer the following responses to the questions raised in the Introduction:

1. TQM is much more than a philosophy; it is a very practical and very rewarding approach to the management of daily operations. The best, most practical way to institutionalize TQM--and to demonstrate its practical application as well--is through the establishment of self-directing work teams.

2. TQM philosophy and the team structure can be implemented with a minimum of organizational disruption, on as small and localized a scale as required, and tailored to a wide variety of organizational needs and structures.

3. Regardless of the organizational setting, the TQM/SDWT structure will, in a relatively short time, yield the promised benefits. By focussing on quality and continuous improvement of the operating process, productivity will automatically improve as well.

ENDNOTES

1/These three philosophies can be found respectively in W. Edwards Deming, Out of the Crisis, Center for Advanced Engineering Study, Massachusetts Institute of Technology, 1986; Joseph M. Juran (ed.), Quality Control Handbook, third edition, McGraw-Hill, Inc., 1974; and Philip B. Crosby, Quality is Free, McGraw-Hill, Inc., 1979.

2/See Also Michael Donovan's three articles, "Self Managing Work Teams," "Employee Involvement Trends for the Decade Ahead," and "Employees Who Manage Themselves," published by the PDS Center for Work Redesign as Reprints 01, 02 and 03, in 1986 and 1988; and Brian Dumaine, "Who Needs a Boss," Fortune, May 7, 1990.

3/For more information on QFD, see Robert King, "Listening to the Voice of the Customer: Using the Quality Function Development System," National Productivity Review, Summer 1987; and John R. Hauser and Don Clausing, "The House of Quality," Harvard Business Review, May-June 1988.

"EMBRACING THE DEMONS OF TRAINING DEVICE ACCEPTANCE TESTING - THE PROCESS IMPROVEMENT LEGACY"

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ABSTRACT

Under the auspices of Total Quality Management, a small group of Government and industry specialists examined the existing training device acceptance test process for potential improvements. The agreed-to mission of this Air Force/Industry partnership was to continuously identify and promote implementable approaches to minimize the cost and time required for acceptance testing while ensuring that validated performance supports the operational training requirements. Application of a process improvement model focused on the customers and their requirements, analyzed how work was accomplished, and led to the identification and elimination of several non-value added components in current test practices.

Diverse technical and management approaches were blended into a single improved process known as Simulator Test 2000 (ST 2000). ST 2000 integrates timely, accurate, streamlined test documentation, provides safeguards for increased confidence in contractor verification testing, and improves on-time test milestone performance via an optimum balance of government/contractor specification performance validation procedures. By testing at a functional level in lieu of detailed testing constructs, this customer oriented approach emphasizes operational checks to determine ability to satisfy training objectives and eliminates Government repetition of previously conducted contractor tests. ST 2000 methodologies have been melded into two new Air Force training initiatives, the Simulator for Electronic Combat Training and the Euro-NATO Procedural Trainer Modernization Program.

Further improvement highlights are those for contractor test performance incentives and commercial-type warranties. Award fee provisions have been included in the Special Operations Forces Aircrew Training System program which allow for tailoring the incentives to reward exceptional test performance. For the Digital Radar Land Mass System under development for the F-16 Weapon Systems Trainer, test incentives are now an essential ingredient. Test Blue Ribbon status would be awarded to those contractors demonstrating absolutely superior test data item preparation, prompt and accurate test discrepancy correction, and a sterling quality program. Yet another far-reaching proposal is to develop simplified straightforward performance warranties. These have been designed to ensure training equipment will conform to its respective specification for periods up to one year following government acceptance.

To significantly reduce the number of Government test requirements, the joint Air Force/Industry team has formulated a total of 27 complimentary recommendations surrounding the test process. These improvements are estimated to save in excess of 40 percent of Government test time without compromising test objectives. This paper describes the development of these training device acceptance test improvements and the status/results of their implementation.

INTRODUCTION

When late during the summer of 1989, President Bush selected John Betti for nomination as Under Secretary of Defense for Acquisition, Total Quality Management (TQM) was fast becoming more than a household word. In fact, TQM was on a course destined to become an intrinsic management philosophy within the Department of Defense (DoD). For purposes of this paper, consider TQM as a leadership philosophy that creates a working environment which promotes trust, teamwork, and the quest for continuous improvement. Other essential elements of TQM require dedication, conviction, and a willingness to bring about change, to do the right things right, the first time, with the ultimate goal being customer satisfaction.

At about the same time as Betti's nomination, the Training Systems System Program Office at Aeronautical Systems Division (ASD/YW), Wright-Patterson AFB, Ohio was plowing new and fertile ground with contractors from the training system industry. Chartered in August 1989, the YW/Industry Total Quality Steering Group developed a mission "...dedicated to continuous process improvement and the acquisition of training products and services to produce the best trained aircrews and maintenance personnel in the world". The primary thrust of this Government/industry forum was to identify and provide recommendations for potential areas to improve the training systems acquisition process using the principles of TQM.

THE CRITICAL PROCESS TEAM. The Critical Process Team (CPT) was chartered by the Steering Committee to investigate a high level cross organizational process having a critical impact on satisfying the customer's requirement. Membership represented a cross-section from the training systems development industry and included the following companies:

- o CAE-Link Corp
- o ECC International Corp
- o FlightSafety Services Corp
- o Hughes Simulation Systems Inc
- o Loral Defense Systems Division
- o McDonnell Douglas Training Systems Inc

Membership from the SPO consisted of two functional experts representing the disciplines of Engineering and Test Management. The team first defined the testing process, then identified the owner of the process, and developed a system to recommend action on improving the process.

Testing is the primary means by which a training device is evaluated for compliance of the design/product against required characteristics and system performance. Through a process of verification, validation, and authentication, the adequacy of performance characteristics are determined along with identification of deficiencies in system performance. Acceptance testing is defined as any and all contractor and Government activities performed to verify device conformance to specified system subsystem performance requirements.

The test process provides contract closure, and allows training initialization. Yet, despite its importance, the test process and accompanying test documentation has been reported as byzantine at best. Many myths and misinformation abound. There is widespread belief, for example, in the following:

- o Acceptance testing contributes to schedule delay
- o The Government must witness all acceptance tests

The Cumberland Group, a subsidiary of Armco Steel, conducted an intensive four day workshop to train CPT members to analyze and improve the process. The Training Systems SPO agreed to fund the training for each CPT member. Team members gained a common understanding of the CPT purpose and were able to come to a consensus on how the acceptance test process is a summation of activities which must be completed in the course of providing a product or service. Effective working relationships were established and the team structure was created. Training provided the beginnings of an understanding of the Cumberland Process Improvement Model methodology.

THE PROCESS IMPROVEMENT MODEL. The objective of process management is to focus on the customers, determine what their requirements are, analyze how work will be accomplished, and identify and eliminate the sources of waste in the process.

The Cumberland Process Improvement Model consists of five primary steps leading to the elimination of nonvalue added components. The model stresses that quality problems are very often rooted in the process that produced them. A change in the process, therefore, is required to achieve meaningful improvement and not just merely eliminate the symptoms. This is the foundation upon which the process management approach to quality improvement is built. Following is a brief description of each step in the process improvement model.

Definition of the Improvement Opportunity: To develop a clear understanding of the team's task, desired expectations were clarified. A flow chart of all acceptance test activities was constructed to better understand the process. Finally, indicators (measures) of improvement were agreed upon to guide the team as it searched for areas of process adjustments.

Data Collection: A questionnaire, based on the measures of improvement was developed and used for data collection to move from the statement of the problem to a more complete description of the current process. Benchmarking of similar processes was initiated. Performance measures of several completed Government test programs were then documented for subsequent process analysis.

Analysis of Improvement Opportunities: Data collected from the previous step was used to identify and prioritize waste and focus efforts on the high payback areas. Waste is defined as any activity that does not add value to the process and was viewed as the primary opportunity for improving the process. In the final element of this step, the root causes of each major waste area were identified.

Development of Solutions: The intent here was to generate alternative ways to eliminate root causes of waste. The team concentrated on ways to significantly change the process instead of merely making minor adjustments. With no assumed constraints, the "perfect" process was visualized to form an understanding of what could really be achieved, even if in stages rather than all at once.

Improvement Recommendations: This final step was designed to improve the current acceptance test process through a series of recommendations resulting from solutions developed during prior analysis steps. Continual improvement is made by planning the modification, engaging the plan, then checking and making adjustments based on the results.

DEFINITION OF THE IMPROVEMENT OPPORTUNITY

The process of developing a clear understanding of the CPT's task and clarifying expectations for improvements in simulator testing was the team's first major assignment. The mission statement that follows was developed in order to clearly define the purpose and reason for existence of the CPT:

"We are the YW/Industry Partnership CPT, committed to continuously identify and promote implementable approaches to minimize the cost and time required for acceptance testing of aircrew and maintenance training devices and to insure that these devices support the users' needs."

The test process was initially defined and a flow chart constructed to depict the acquisition tasks used in training device development. The flowchart shown in figure 1 depicts typical test activities and may vary somewhat depending on a particular program's requirements. Review of the existing process revealed that there were several test repetitions, multiple Test Readiness Reviews (TRRs), and numerous possible delay paths.

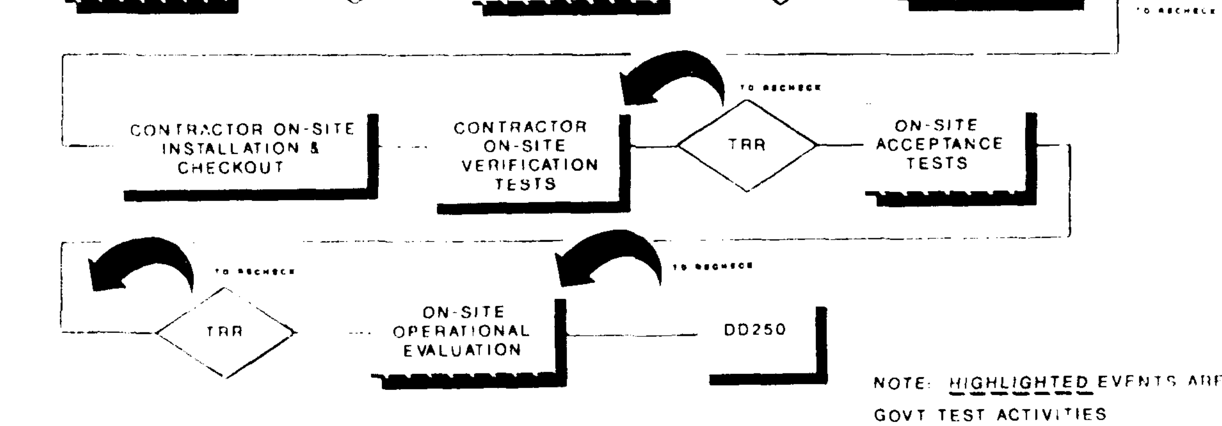

FIGURE 1. CURRENT SIMULATOR TEST APPROACH

Process indicators were used to measure the performance of the acceptance test activities. Two approaches were used to generate the process indicators. First, the CPT membership produced a list of parameters which measured the performance of the acceptance test effort based on specific testing experiences. The second approach was to define measures relating directly to the delay loops in the process flowchart. Finally, the two lists were evaluated with reference to the following criteria:

a. If the test process is revised, will the proposed indicators be able to measure the improvement?

b. Can the indicator be measured in real terms using objective results?

c. Can data be obtained from the companies, is it something likely to be measured and retained as part of the existing testing process?

d. What is the most important data to request?

The final list of process indicators totaled 38 distinct measures. The CPT focused on the four top indicators to collect data for further analysis.

Test Milestones Met or Delayed: The first indicator was based on schedule milestones required to conduct a test program. Program and contract schedule events were chosen in anticipation that such data would be recorded and available.

Number of Test Discrepancies: The number of Test Discrepancies (TDs) generated during acceptance testing is a measure of the training device quality. To get more insight into the causes of TDs, data was requested to include total number of TDs, number of TD re-submits, number of post sell-off TDs, and number of TDs out-of-scope.

Number of Days in Test: The purpose of this indicator was to isolate schedule variances by measuring duration of key test events (planned days vs. actual days). From the results, the CPT selected three phases to measure test duration as a performance indicator. These were in-plant development tests and on-site acceptance and operational evaluations.

Test Documentation: The CPT membership considered test documentation excessive. The size of the test procedures, i.e., number of pages, was the means used to measure this excess. In addition, the detail to which the procedures were written was measured by the number of test steps per page.

After settling on which indicators to be used, it was then necessary to consider the possible sources of data for the information the CPT needed. In determining the selected programs, the CPT focused on recently completed test programs and the likelihood of gathering accurate data. Finally a questionnaire which focused specifically on the process indicators was developed and used to gather supporting data.

BENCHMARKING

Benchmarking is the concept of "who does it best". The approach was to identify possible candidates for the CPT to evaluate as "best." The benchmark selection criteria included stringent testing and the use of commercial practices relating to the CPT process indicators. Candidate sources were:

- o Airline simulator programs
- o Simulation industry
- o TQM award winners
- o Other TQM intense companies
- o NASA simulators

The replies to the CPT membership inquiries and questionnaire were extremely poor. Successive follow-ups by team members did little to elicit further responses. Many indicated they felt their testing approach was sufficiently different to make it unsuitable for our purposes. It rapidly became apparent that integration and test of a full flight simulator is a uniquely challenging task not commonly encountered in other industries.

At that point the team decided to focus on the commercial airline simulator industry as the candidate for "best". This was based on the fact that they buy/build a product similar to the Air Force, use commercial standards, and must pass stringent acceptance testing conducted for/by the FAA. Seven commercial devices provided adequate data for benchmarking.

The raw data from the questionnaire was analyzed and incorporated into summary sheets. Several very important adjustments were made to produce the summary sheets. The first adjustment was to eliminate companies/programs that did not respond to the questionnaire and those who felt their process was different. In addition, programs were excluded if sufficient data was not available. For example, only limited data was provided for maintenance trainer programs apparently due to less stringent test requirements. Comparison data was therefore nonexistent. As a result, six military programs and seven benchmark commercial programs remained for further evaluation as contained in the final summary sheets, tables 1 and 2.

ANALYSIS OF IMPROVEMENT OPPORTUNITIES

There is a fine distinction between a problem and an opportunity. In this phase of the CPT effort, as problems were substantiated, opportunities became apparent. The predominant issue was then to focus/select opportunities that satisfied the mission statement.

MILESTONES MET/DELAYED (DAYS)	GBU-15	F-15E LANTIRN	F-16 ADF	AV-8B	EF-111 OFT	F-15E WST
Start TRR	-182	-31	-245	-4	0	-199
Devel/Engr Test Complete	-198	-31	-240	0	-300	-257
Ship	-201	0	-240	0	UNK	-318
Start On-Site Acceptance	-201	0	-219	0	-300	-329
Finish On-Site Acceptance	-211	0	-217	0	-332	-330
Ops/FAA Eval On-Site	-213	0	N.A.	0	-345	-318
DD-250/Sell-Off	-213	0	-217	-30	-385	-330
TEST DISCREPENCIES						
Total Number of TDs	94	638	83	557	1209	1100
Number of Resubmits	5	20	UNK	28	UNK	48
Post Sell-Off DD-250	0	92	4	81	102	0
Out of Scope	0	13	0	20	UNK	1
TEST PHASE DUR'N (PLAN/ACTUAL DAYS)						
In-Plant Devel Test	18/29	18/18	10/5	38/54	70/300	156/149
On-Site Acceptance	14/11	5/6	5/3	42/42	30/32	21/*
On-Site Ops/FAA Eval	30/30	10/10	N.A.	9/9	10/10	14/*
Total Plan/Total Actual **	62/70	33/34	15/8	80/96	110/342	191/*
TEST PROCEDURE						
Number of Pages ATP	400	862	461	4950	2400	6500
Steps per Page	2.5	0	7	5	7	7
Percent Inspection	48%	5%	46%	14%	20%	29%
Percent Analysis	11%	5%	4%	9%	27%	16%
Percent Demonstration	41%	70%	32%	47%	17%	37%
Percent Test	0%	20%	18%	30%	35%	18%

NOTES: * - Test Phase Not Complete
** - Excludes Teardown, Pack, Ship, On-Site Install and Checkout Activities

TABLE 1. QUESTIONAIRE DATA - MILITARY PROGRAMS

MILESTONES MET/DELAYED (DAYS)	BCAC 737-300	US AIR 737-300	DELTA MD88	NWA A-320	DELTA 757	UAL 747	FS C-5B
Start Test	5	-65	-110	*	*	0	0
Devel/Engr Test Complete	21	-75	-160	*	*	0	0
Ship	25	-47	-183	-24	UNK	0	0
Start On-site Accept	14	-53	-149	14	27	0	0
Finish On-site Accept	-5	-53	-164	-3	-4	0	0
Ops/FAA Eval	-4	-53	-164	-7	-9	0	0
Sell-Off	-2	-54	-157	-4	-10	0	0
TEST DESCREPENCIES							
Total No. of TD's	607	451	544	374	275	810	1040
Number of Resubmits	75	62	162	40	30	30	236
Post Sell-Off DD250	42	21	27	237	25	150	224
Out of Scope	24	UNK	27	0	7	10	10
TEST PHASE DURATION (PLAN/ACTUAL DAYS)							
Inplant Devel Test	51/35	20/30	30/80	*	*	35/35	60/60
On-Site Acceptance	15/34	20/20	30/45	40/44	48/79	15/15	30/30
On-Site Ops/FAA Eval	5/2	3/3	3/2.5	3/3	3/3.5	3/3	3/3
Total Test/Total Program	71/71	43/53	63/127.5	43/47	51/81.5	53/53	93/93
TEST PROCEDURE							
No. of Pages ATP	1000	2000	2000	2453	2400	UNK	1774
Steps per Page	10	4	2	6	6	UNK	6
Percent Inspect	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Percent Anal	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Percent Demo	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Percent Test	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

NOTES: * - **In-Plant Test Not Planned, These Are Production Units**

TABLE 2. QUESTIONAIRE DATA - COMMERCIAL PROGRAMS

After being reviewed for omissions, the raw data was organized for the purpose of identifying waste areas in the test process and subsequently determining the root causes. The data was grouped according to the four process indicators and studied for information and/or conclusions that could be drawn from the data sets. The data was plotted to obtain a visual representation and studied to identify relationships, trends and observations.

IDENTIFICATION OF WASTE AREAS. Each chart was individually reviewed to search for waste areas in the test process. Graphical analysis assisted in producing a better definition of the problems. The team used tabular data, histograms, the process flowchart, and comments on the questionnaires for identification of process waste areas.

Eight critical waste areas were identified for subsequent root cause analysis. Root causes were uncovered by systematically questioning why the waste exists until the root cause is identified. This was done by asking "why" five times. Simple as this may sound, root causes were determined for each waste area using this method.

WASTE AREAS

1. Delay in start of test.

The following root causes were identified by the CPT as being directly related to test delays:

- o Late Government identification of minimum training needs
- o Poorly defined requirements
- o Incomplete design
  - Requirements not complete
  - Data not available
  - Resources not available
  - Inefficient implementation of new technology
- o Manufacturing not complete
  - Government Furnished Equipment (GFE)/Contractor Furnished Equipment (CFE) not available
  - Inadequate subcontractor/vendor management
- o Hardware/Software Integration in-process measurement criteria lacking

2. Redundant testing.

The following root causes were identified as contributing to the problem of redundant testing:

- o No Government recourse after buy-off
- o Improper engineering test procedures
  - Engineering procedures not repeatable
  - Results not documented

3. Detailed customer subsystem Performance verification.

The CPT identified the following root causes as contributing to overly detailed performance verification testing:

- o Contractor test results not available or documented
- o Traditional, bottoms-up test techniques
- o Performance risks associated with new technology

4. Test Discrepancies.

Examination of TDs as waste areas yielded the following root causes:

- o Lack of trained resources
- o Invalid test procedures
- o Poorly defined operational performance
- o Data shortfalls
- o Incomplete contractor testing

5. Excessive test Documentation.

Contributing to the problem of excessive documentation, the following root causes were identified:

- o Documentation is overly complex and detailed providing for
  - Repeatability
  - Skill level
  - Support considerations
  - Test Matrix requirements
- o Documentation is not coordinated across contract requirements
  - Micro management

6. Test Interruptions.

The following root causes were identified as causing schedule interruptions:

- o GFE/CFE spares not available
- o Schedule pressure
  - Acceptable risk
- o Poor systems analysis/solutions unsatisfactory
- o Customer facility not ready
  - Lack of control of the construction program
  - Lack of contractor design
- o Software update process errors

7. Multiple test readiness reviews.

A singular root cause was identified generating multiple TRRs:

- o Failure of the contractor to be ready for test

8. Computer Program System Generation (CPSG).

The following root causes were identified as contributing to CPSG requirements:

- o Lack/weak contractor software tools
- o The requirement to accommodate changes

IMPROVEMENT RECOMMENDATIONS

The CPT is recommending fundamental changes to the acceptance test process and activities supporting that process. These recommendations are based on analysis of the current test methodology and solutions formulated by the team to eliminate the root causes for identified wastes. The recommended new process known as Simulator Test 2000 (ST 2000) is shown in Fig 2. When contrasted against the current test process (ref Fig 1), the elimination of redundant Government CPSG testing, in-plant performance tests, and on-site acceptance tests becomes obvious. Accountability will be improved by better aligning authority with responsibility for Government and contractor development test teams. Unnecessary testing will be eliminated, test documentation will be minimized, and the level and type of testing will be more focused on satisfying training requirements. In addition, a comprehensive and more effective test assessment will be realized without extensive TRRs. Test procedures will be elevated to the functional level and Air Force Subject Matter Experts (SMEs) will be made available to assist the contractor during systems development. Test functionality will not be reduced nor will test integrity be compromised as a result of the recommendations proposed in ST 2000.

The CPT concentrated on the task of improving the efficiency of acceptance testing. However, "testing" encompasses and is influenced by a much broader span of activity outside the formal test program. Program development tasks prior to acceptance testing were suspected by the CPT membership of masking problems which subsequently appear during or delay the start of acceptance testing. The data collected supports prior suspicions. CPT findings show a major cause for delay in fielding acceptable training devices is due to activity that precedes the start of acceptance testing. In particular, recommendations made in the areas of design data, aircraft components, and Hardware/Software Integration are emphasized because of their known historical impact on the test program. Correction of these problems will largely avoid significant delays experienced on past programs.

RECOMMENDATIONS. The following represents the total list of detailed recommendations made by the CPT.

1. Implement the Simulator Test 2000 process. (Source: Process Analysis)

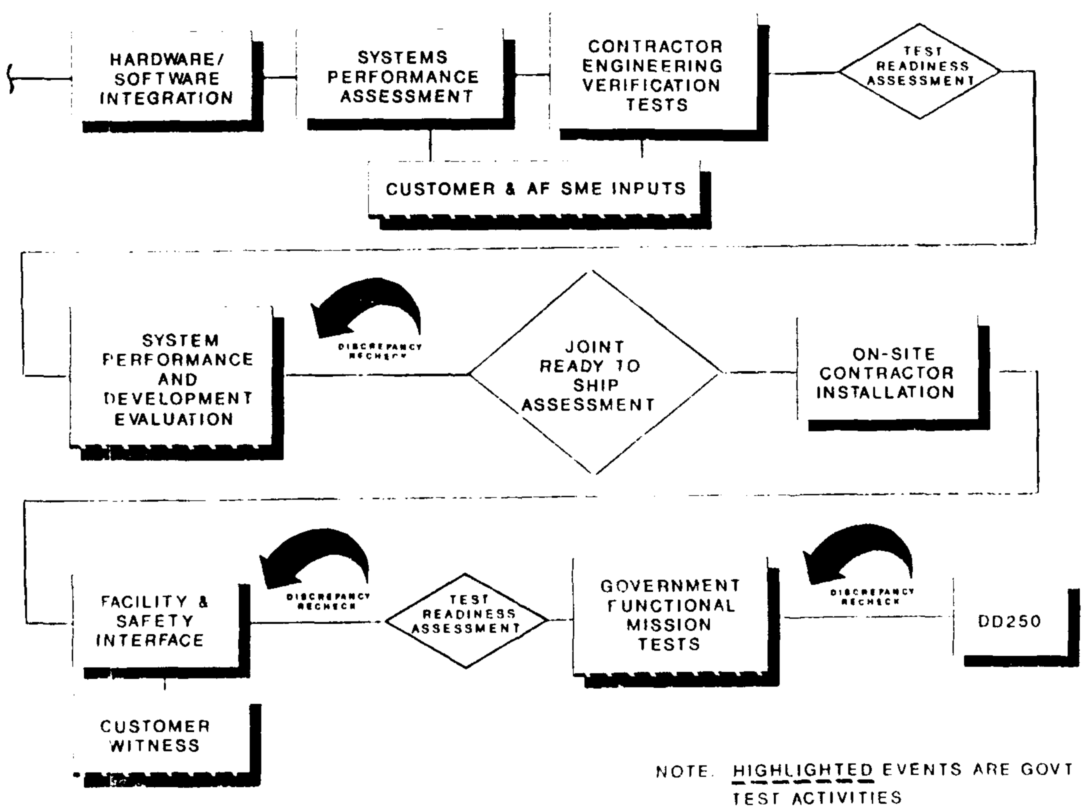

FIGURE 2. SIMULATOR TEST 2000

a. Engineering development tests should be performed and results submitted to the Government for acceptance to eliminate redundant tests. (Source: Waste Areas 2 and 3)

b. To minimize ambiguous design requirements and avoid the tendency to redesign during both contractor and Government test phases, the Government will make SMEs available to assist in subjective evaluations. Subjective data will then be quantified and incorporated in the DCL. (Source: Waste Areas 1, 2, and 4)

c. Greater emphasis should be placed in the SOW to automate test routines similar to FAA Advisory Circular 120-40 commercial airline requirements to produce reliable, and repeatable results and alleviate the need for redundant Government tests. (Source: Waste Areas 2 and 5)

d. Government test procedures should be written at a functional level to facilitate System Performance and Development Evaluation (SPADE) and Government Functional Mission Tests. (Source: Waste Area 5)

e. The training system developer should manage a single discrepancy status accounting system to eliminate duplicative and often disparate systems. During test, an ad-hoc team to identify and manage the resolution of "show stopper" TDs should be established. (Source: Waste Area 6)

f. The SOW should emphasize automated error detection in the software compile/load build process to drastically reduce software generation errors. (Source: Waste Area 6)

g. Reduce the number of TRRs to minimize delays in the test schedule by shifting the burden of test readiness to the contractor. (Source: Waste Area 7)

h. Provide the training system contractor the opportunity to eliminate Government CPSG and realize schedule and resource economics through advanced Government certification of software configuration management systems. (Source: Waste Area 8)

2. A well defined and realistic Training Systems Requirements Analysis should be developed prior to release of the RFP to establish and bound training tasks early in program development. (Source: Waste Area 1)

3. Make SMEs available to the training device contractor early in the program to help resolve data deficiency problems and establish consensus on interpretation and application. (Source: Waste Areas 1, 2, and 4)

4. Implement the Simulator Data Integrity Program study recommendations to ensure timely, accurate, and complete data availability to the training device developer from the weapons system design contractor. (Source: Waste Area 1)

5. Establish an Industry lead CPT to investigate solutions to incomplete Hardware/Software Integration planning including start, stop, and in-process measurement criteria. Improved management of this important development step is critical to Contractor Engineering Verification Tests (CEVT). (Source: Waste Area 1)

6. Mitigate technical performance and schedule risks by using prototype testing to mature new technology applications prior to attempted insertion into Hardware/Software Integration. (Source: Waste Areas 1 and 3)

7. To relieve the schedule delays attributable to unavailable or late aircraft components, early identification of requirements (including spares) followed by obtaining sufficient priority for timely acquisition from the weapons system contractor is considered essential. Components could be manufactured or alternately provided by the training system developer via an associate contract agreement with the weapons system developer. The use of equivalent commercial standards and nonmilitary components designed for foreign governments should be encouraged. (Source: Waste Areas 1 and 6)

8. Prime contractors must strengthen subcontractor/vendor management processes to improve delivery performance and reduce the impact on device readiness. (Source: Waste Area 1)

9. Require more aggressive, comprehensive performance warranties to crystalize contractor liability and bolster Government confidence in contractor assertions to "meet the specification." This will radically reduce contract test requirements. (Source: Waste Area 2)

10. Contract specification test requirement definitions must be clarified to assure current application of test techniques for performance validation. Traditional bottoms-up testing would virtually be eliminated. Test application should be determined at design reviews. Additionally, MIL-PRIME Air Force Guidance specifications 87241 for flight simulators and 87228 for maintenance training devices requires revisions to include test definitions. (Source: Waste Areas 3 and 5)

11. Training of contractor test personnel in the principles of TQM would greatly improve product quality. Reduction in discrepancies and a more thorough accomplishment of procedures would practically be guaranteed. (Source: Waste Areas 4, 5, and 6)

12. CDRL responsibilities should be centralized with the Government lead engineer to avoid duplication of unnecessary and uncoordinated test documentation requirements. (Source: Waste Area 5)

13. Institute a program to allow pre-approval of contractor plans required for Government oversight to eliminate the need for separate plans for each program. (Source: Waste Area 5)

14. To abate the impact of test interruptions, risk management programs must be developed and implemented to anticipate and manage possible causes. (Source: Waste Area 6)

15. A repair pipeline should be negotiated with the original equipment manufacturer prior to testing to insure the availability of spares during the test program. (Source: Waste Area 6)

16. Training device development programs requiring new/modified facilities should consider tasking the development contractor as authorized by 10 USC 2353 to centralize contract engineering responsibilities. (Source: Waste Area 6)

17. Remove test duplication that exists in software at the Computer Program Component and Computer Program Configuration Item level (between 2167A and acceptance test requirements) by revising 2167A criteria. (Source: Waste Area 2)

CPT GENERATED RECOMMENDATIONS.
Through the efforts of identifying areas of waste, the team has formed additional recommendations viewed as critical. Three general recommendations are made to improve Government and contractor test program efficiency through contract provisions relating to contractor performance and are strongly recommended.

Test Blue Ribbon Contractor Program: The CPT endorses development of an contract provision to reward superior contractor test performance. The purpose is to formalize waiving test program past performance assessment requirements once a contractor has demonstrated exceptional compliance to contract requirements. This provision recognizes that even among responsible contractors, varying degrees of quality and test programs exist.

An integral part of this program is the development of a Blue Ribbon Contractor list for simulation and training device manufacturers participating in either firm fixed price or cost plus contracts. Membership on this list indicates a contractor has demonstrated dependable quality and test program performance on Air Force contracts during the past year. The Blue Ribbon Contractor List is intended to be a major factor in the evaluation of past quality and test program performance.

At least semi-annually The Training Systems SPO will convene a panel to review contractor applications for membership on the Test Blue Ribbon Contractor List. The panel will use Government data to validate a contractor's application. Data recommended may include: Test Discrepancy Management System, Data Item Tracking System, and Contract Administration Office maintained data, including documented records of the contractor's Quality Program. Those contractors meeting or exceeding the membership criteria will be placed on the Test Blue Ribbon Contractor List.

It is proposed that contractors whose names appear on the Blue Ribbon Contractor List would not be required to submit past performance data with any proposals responding to RFPs. In addition, Contractor Performance Assessment Reports as required by AFSC regulation 800-54 will require no evaluation in the test and evaluation area for qualified contractors. Simply inserting "Test Blue Ribbon Contractor" would suffice. The CPT urges this be implemented at the earliest possible opportunity with the concurrence of the Training Systems SPO Program Director.

Contractor Test Performance Incentives: The CPT recognized that the contractor currently has every incentive to start Government test to see if he can "selloff" the device and save schedule. If testing fails to achieve the desired result, the contractor may find it more economical to resist corrections, attempt short term solutions, and hope test schedule concerns will cause the Government to weaken its position.

The CPT believes that exceptional contractor test performance should be rewarded. Conduct of an effective, well planned test program is a worthwhile objective. The creation of contract incentives to accomplish this, however, is dependent upon several variables including the basic nature of the testing (development vs. production), the type of contract (cost vs. fixed price), and the type of incentive (i.e., objective performance incentive versus subjective award fee incentive). These factors, along with other pertinent facts, must be weighed when trying to assess the ability to create a "real" contract motivator. The ultimate question to be satisfied is "What motivates the contractor?" Is it profit, sales, cash flow, etc.? The answer lies in the contract type which is what inspires motivation.

Development Testing - Cost Type Contract - Award Fee: Because of the very nature of a development program, it would be extremely difficult to structure a performance incentive which would be meaningful. Development testing by its very nature is intended to surface problems before the design is frozen and moved into production. The key is solid test planning and analysis in order to minimize surprises. These areas tend to be quite subjective when attempting to establish measurement criteria. Additionally, if work is being performed under a cost type contract, the need to get the hardware bought off in order to liquidate cost and gain profit is nonexistent. Award fee provisions would allow tailoring of the incentive from period to period as the program progresses and provide multiple opportunities to reward performance.

Production Acceptance Testing - Fixed Price Type Contract - Performance Incentive: In a production environment, test requirements are usually quantifiable. Because of this, the Government's ability to write a meaningful incentive at the time of contract award is much greater. A concern remains that the incentive being structured is sufficient in terms of dollars or corporate visibility to be an effective motivator and is in balance with the remainder of the program. From a cash flow or liquidation standpoint, the contractor is still motivated to push for contract buy off in order to claim progress payments and profit. Additionally, the incentive must be justifiable in terms of overall savings to the Government (i.e., reduced Temporary Duty, more efficient use of personnel, reduced paperwork, etc.).

The CPT recommends that initiatives begun by The Training Systems SPO on the Special Operations Forces Aircrew Training Systems Program and the Digital Radar Land Mass System under development for the F-16C/D weapon system trainer be continued and applied to all new acquisition programs. It is extremely important to monitor results of programs where incentives have been applied to ensure the level of value is worthwhile to the contractor, that they remain realistic and achievable, and experience gained through their application is reinvested in future programs.

Milestone Funding: Firm Fixed Price contract funding/billing milestone schedules may influence acceptance test performance. Excessive financial value is sometimes associated with the shipment of training devices from the contractor's facility. This places significant pressure on the test organization to start Government acceptance as soon as possible and ship before all problems have been corrected and retested in order to capitalize on contract milestone payment provisions. Thus, the contractor may be willing to "take the risk" that problems can be solved during second shift, during the period of equipment tear down, pack, and ship, or during site installation and checkout.

Having the contractor revenue events place less emphasis on the ship milestone could improve overall test performance. The contractor would keep the equipment in plant to complete problem resolution and retest. This approach enables the contractor to conduct testing in-plant which is considerably more cost effective to both the contractor and the Government than post-deployment modifications. Contractor resolutions to problems would likely be facilitated by having total in-plant resources available rather than using "tiger teams" on-site.

The CPT recommendation is to reduce the size of the dollar value associated with training device shipment from the contractors facility. The decision to start acceptance testing should not be influenced by a large contractor revenue event. Instead the contract funding profile should place more emphasis on final on-site acceptance testing. The contractor would still be motivated to finish as soon as possible but would no longer be incentivized to prematurely ship the device.

CONCLUSIONS

The premier improvement to simulator and maintenance trainer test process has been identified as Simulator Test 2000. Reforms to reduce Government test, strengthen and reallocate contractor test responsibilities, refine test documentation, and discrepancy management encompasses major CPT recommendations.

For any recommended process change to be considered for implementation, a measurable improvement must be expected. If there is a significant anticipated benefit as a result of the new process, a high degree of motivation to adopt the new process will be present.

A comparison of the current simulator test approach shown in Fig 1 and referred to here as the "Idealized Weapon System Trainer (WST) Test Program", can be made to the ST 2000 process. The Idealized WST Test Program assumes that once testing begins, it progresses and is completed without delays or interruptions. This test program includes CVT, Performance and Acceptance Tests, and in-plant as well as on-site Operational Evaluations as depicted in Table 3. The total test effort of forty-eight (48) weeks required by the idealized WST test program can then be compared to estimates for a WST using the ST 2000 process as shown in Table 4. It can be seen that the reduction of the total test effort from forty-eight (48) weeks to thirty and one half (30.5) weeks represents a savings of approximately thirty-seven (37) percent.

Table 3. Idealized WST Test Program

	IN-PLANT			ON-SITE		
TESTS:	CVT	Performance Test	Ops Eval	Acceptance Test	Ops Eval	TOTAL
WEEKS:	20	18	2	6	2	48

Table 4. ST 2000 Process

	IN-PLANT			ON-SITE	
TESTS:	System Assesment	CEVT	SPADE	Functional & Mission Tests	TOTAL
WEEKS:	1.5	20	6	3	30.5

The consensus of the CPT members is that with the adoption and implementation of the ST 2000 process, a significant savings in resources can be realistically expected if all elements of ST 2000 process are implemented.

Additionally, if the other recommendations and suggested changes are also implemented, increased efficiency in training device acquisition programs can be achieved. These are outside the formal test phase, but directly affect the start or progress of testing. The potential savings to cost/schedule which can be achieved by implementing these changes are not to be overlooked. The largest waste in most military training device development programs occurs, for a variety of reasons, prior to the device being ready for testing. A review of the start TRR milestone data from Table 1 shows that on average military programs are 132 days (26.5 work weeks) late prior to beginning of test. The elimination of this waste would result in cost and schedule overrun savings of approximately eighteen (18) percent over the life of a planned thirty-six (36) month program.

The most significant process change is the customer's agreement to accept CEVT test results. Repetition of these types of specification compliance tests by the Government are no longer a requirement. This commitment eliminates the single largest cycle of customer testing from the current acceptance test process.

In point of fact, ST 2000 places the responsibility to thoroughly execute CEVT squarely on the contractor. It must be conducted to the same level as required for developmental performance testing previously conducted by the Government. This means that test results must be documented, verifiable and repeatable. Failure to execute stringent, valid testing with documented results will motivate the customer to demand a repeat of previously run tests and will again require 100% witnessing of CEVT. If the contractors do not perform their part, the customer has no alternative but to revert back to the existing test philosophy. The customer has extended the opportunity, the contractor must aggressively respond for ST 2000 to be viable.

ENDNOTES

1/ Winter, F.J., et. al, "Process Improvements In Training Device Acceptance Testing - A Study In Total Quality Management" USAF ASD TR-90-5000, Dec 12, 1990

2/ Shaw, J. and Lloyd, William "Bridging the Information Gap." Proceedings of the Eleventh Interservice/Industry Training Systems Conference, (November 1989)

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That the development of training device acceptance test improvements have proceeded so rapidly, to such successful outcome with such a far-reaching impact, is a testimonial to the vision, skills, and dedication of this highly motivated and professional team. Those useful insights contributed greatly to the development of this paper.

MISCELLANEOUS

DEFENSE INFORMATION RESEARCH AND ACQUISITION:
HOW TO CREATE A MISSION-ORIENTED DEFENSE INFORMATION RESOURCE CENTER THAT MEETS YOUR COMPANY'S NEEDS

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ABSTRACT

Defense contractors are continually faced with the dilemma of acquiring information from government sources that are unfamiliar and/or necessarily controlled. This task has been made even more difficult by the recent interim rule established by the Secretary of Defense that severely restricts the release of acquisition related information.[1] The Defense industry must be able to identify ever-changing customer requirements to win contracts and then must be able to access a plethora of information to deliver products and services that conform to a wide range of government specifications, standards, regulations, and otheryard sticks against which performance will be measured. This is no small obstacle to even the largest contractors and may seem to be an impossibility to new or emerging companies. It can also be expensive. Without a well developed information plan, a company can quickly squander its limited information research funds among a myriad of possible resources without acquiring all the data it really needs.

This paper provides an overview of the unique mission-oriented Defense information center developed at The Johns Hopkins University Applied Physics Laboratory over a 15-year period. It also outlines the steps recommended to establish a similar information center for any Defense contractor.

INTRODUCTION

Predictions of social, political, or economic scenarios for our country are tentative at best, especially in a world undergoing the most dramatic changes since World War II. However, nothing on the national or international horizon appears to change the fact that the Defense budget is likely to decline steadily over at least the next decade. There are two principal reasons for this decline: first, the disappearance of the Soviet Union as the major strategic threat and the raison d'etre for many Defense programs and force levels and, second, the

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[1]Subcontractor with The Johns Hopkins University, Applied Physics Laboratory.

increasingly intense competition for scarce discretionary funds. Among the many competitors for these funds are the Savings & Loan bailout (banks too?), the cleanup of toxic waste sites and manufacturing plants for nuclear weapons, space exploration and the Mission to Planet Earth, and the increasingly difficult funding of the national debt.

Even with the current increase in Defense stocks resulting from the Persian Gulf war, the message is clear: for the foreseeable future, there will be less work and less money to sustain the huge Defense industry that grew out of the Reagan years. Some companies will successfully move into non-Defense programs; some will remain Defense-oriented and will survive the austere economic climate; and, inevitably, some will fail. Those companies that do survive will be leaner and smarter, produce higher quality products, and have a better understanding of the government marketplace. No longer will they be able to rely on past reputation and performance to bring new work in the door. They will need a strategic plan that reflects the changing requirements of their customers. More than ever, they must be able to acquire information to map out new market directions and opportunities and to carry contracts through to successful completion. This requires not only mission-oriented information systems but also trained professionals to operate them. While there have been many recent advances in information technology, little emphasis has been placed on the development of information professionals to support the Defense industry.

To address this situation, this paper will first describe the mission, information needs, and information solutions that are being developed at the Applied Physics Laboratory of The Johns Hopkins University. Some recommendations on how other Defense contractors might develop similar solutions will then be presented.

THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

Background

The mission of The Johns Hopkins University can be stated as public service through education, research, and the application of knowledge to human affairs. As part of the University, the Applied Physics Laboratory (APL) shares this purpose through the application of advanced science and technology to the enhancement of the security of the United States of America and through basic research and participation in the educational programs of the academic divisions of the University to which its staff and facilities can make an especially favorable contribution. APL was organized in 1942 under the auspices of the Navy's Office of Scientific Research and Development to meet urgent requirements of the fleet for air defense. Following the War, the Laboratory continued to support our Nation's defense needs, with its primary orientation remaining to the

Navy. Today, APL has a staff of about 3000.

As a nonprofit institution, APL conducts programs of research, development, engineering, testing, evaluation, and assessment to improve the efficiency and assure the viability of current and future Navy tactical and strategic forces. The Laboratory's principal efforts are in the broad areas of fleet defense, fleet ballistic missile system effectiveness, and space systems development. APL formulates advanced system concepts; carries out system engineering and integration; designs and builds prototype and demonstration systems; develops special purpose instrumentation, components, and software; performs simulations; and conducts technical analyses, studies, and operations research necessary for systems design.

In carrying out these programs, the Laboratory is, in effect, an intricate, specialized communication system engaged in the processing of information. It has been said that for such a system "the mission itself is a separate functional area of communication, with mission-related information, and a separate set of rules governing the exchanges that differ from the rules in any other functional area. Mission-based communication contains memory (the past)...and something else too--the structure of the mission itself."[2] The needs for information support at APL flow directly from the mission that has been described, and the solution to those needs is directed to requirements imposed by that mission.

The Needs for Information Support at APL

APL's viability depends on its successful application of information and data from a dichotomous information world. One part of this information world is composed of a relatively open body of literature that supports primarily programs of basic research and exploratory development. Supplying scientific and technical data to Laboratory tasks funded under these categories has long been the principal challenge of APL's central scientific and engineering library. The second part of the dichotomy is composed largely of sponsor- and government-controlled information that must be identified and requested through appropriate channels. This information is associated more with the sponsors' requirements for systems development, fielding, and integrated logistic support than with basic and exploratory research.

APL's Information Solution

Because much of APL's work is not basic research or exploratory development, there is a fundamental need for specialized information gathering that addresses the Laboratory's unique information requirements. This need fostered the formal establishment of the Management and Contracts Information Service (MACIS) in 1978.[3] Initially part of the central library, its resources have been developed into a collection of about 4,000 documents with further information support from appropriate online retrieval sources and imported databases. It presently has a staff of six, including information professionals as well as persons with prior military experience in order to create a blend of talents in information technology and Defense systems subjects, and operations. Approximately 30 requests are handled each month in the following areas:

- New program development. A collection of planning resources is maintained that includes government requirements statements, announcements of opportunities, newsletters, online retrieval systems, and other information that facilitates awareness of new program opportunities suitable for nonprofit organizations and university laboratories. This collection helps APL match its capabilities with the needs of potential sponsors to create new endeavors of mutual interest. Concomitantly, MACIS provides limited consultation and focused analysis to Laboratory management for economic forecasting and strategic planning, particularly for Defense programs.

- IR&D program planning. MACIS provides a wide range of information to help the Laboratory conduct long-range Independent Research and Development (IR&D) planning that remains consistent with sponsor needs, to develop and assess IR&D proposals, and to identify suitable areas for initial or continued investigation.

- The government organizational environment. To simplify interactions with sponsors, potential sponsors, and executive or legislative offices, MACIS identifies government agency organizational structures, personnel, phone numbers, codes, missions, functions, and facility capabilities.

- The regulatory/directive environment. Government agency directives, instructions, circulars, administrative and policy issuances, procurement regulations, and other guiding and controlling documents are supplied to explain what, when, where, how, and by whom things should or must be done.

- Program/project management. Handbooks, manuals, standards, and textual guides covering broad and specific aspects of government R&D, systems acquisition and management, and engineering development are available to support program and project managers at APL.

- Defense/aerospace systems and operational environments. Numerous sources of technical, logistical, and warfare data developed or required during the life cycles of Defense/aerospace systems acquisition and deployment can be accessed to help Laboratory staff perform their tasks.

- Speaking the language. MACIS provides authoritative dictionaries and directories of terminology, codes, acronyms, and abbreviations to translate government bureaucratese into plain language.

• Naval/DoD education and training. Catalogs, directories, and other resources to identify military training courses and manuals that may be required for special task assignments are obtained.

• Security. Classification guides for naval warfare programs, the DoD Militarily Critical Technologies List, and regulations for technology transfer and export control of sensitive information are maintained.

• Data and document preparation. MACIS can supply data item descriptions, rule or source documents, examples of data deliverables, and Computer-aided Acquisition and Logistic Support (CALS) standards; guidelines for acquisition documentation; and other military style guides to help in the preparation of data and documentation required from the Laboratory.

• Data and document identification and procurement. Comprehensive collections of indexes, directories, and catalogs are maintained to identify required publications, data, software, forms, maps, and other information products by type, publication number, associated weapon system platform, system/equipment designation, applicability, or other specified means of identification.

• Custodial control of sensitive publication series. MACIS acts as the Laboratory's designated central point of contact for the procurement and custodial/property control of military publication series that require special accountability.

While MACIS serves a nonprofit contractor that does not have a marketing function, its structure and experiences may be applicable to for-profit contractors as well.

ESTABLISHING A COST-EFFECTIVE DEFENSE INFORMATION CENTER FOR YOUR COMPANY

Getting Started: Obtaining a Mandate from Top Management

The most important consideration in establishing any general or administrative overhead function is securing the support of top management at the outset. There are several ways to do this. For the purposes of this paper, let us assume that the Defense information services to be discussed will be located under a Director for Information, Marketing, and Accounting Systems, perhaps a suitable arrangement for a small but growing company. Further, assume that the company is either just beginning to expand into the Defense business or is already a Defense contractor and is looking for growth opportunities. The information director should look for commitments from top management in three important areas.

• Funding. There must be an appropriate budget allocation to support the information center. Sufficient start-up funding is necessary to identify, acquire, and develop information resources until the center can sell its services to elements of the company and be reimbursed for its expenses. At that point, it should consider operating as a self-sufficient entity accounted for as a profit/loss center.[4] In the interim, the company must cover the start-up costs.

- Staffing. The planning, initial start-up, and future development of the Defense information center will need more than the part-time efforts of existing staff members. New members will be required with special skills and experience not only in information technology, but also in military subject and mission areas from which information will be sought. Most important will be an ability to supplement access to standard repositories of Defense information through direct interaction with cognizant DoD activities. Some knowledge of marketing principles[5] and the essentials of aerospace/Defense contracting are also important.

- Organizational integration. Information centers must know the goals and interests of the organizations they support if the data they acquire are to be useful. This point may seem obvious, but it is surprising how many companies create information centers to produce market intelligence and technical or other vital information, yet bury the centers under many layers of management. Lacking any real guidance or orientation from top management, the information services provided are likely to become stale or inappropriate for the company's evolving business interests.

Companies that establish information centers without a real commitment in resources and adequate integration are apt to generate information that never seems to be quite what the company needs.

Identifying and Analyzing Your Company's Information Needs

One of the more difficult aspects of providing Defense information is identifying exactly what information is required. This is true for established as well as new information centers, both of which must continually develop and match information resources and capabilities to evolving needs. The task of identifying information needs is similar to that performed by systems analysts in developing a management information system. In fact, the analysis of information needs is a logical step in the development of any information system.

Assessing information needs should include a review of organizational missions, strategic plans, goals, policies, budgets, and other internal documents to identify existing programs and future plans. This step is essential for acquiring a broad understanding of the company's customers, the types of defense programs that are being funded, and the level of funding for each--an important guide in setting information service/resource priorities. Following this basic research, the information analyst should talk to key members of management, line department supervisors, program managers, and anyone involved in marketing to develop an awareness of the deliverables expected from current programs, information needed to support current operations, and any deficiencies (actual or perceived) in specific market information.

Sources of Help to Avoid Pitfalls

Although training is available for the technical program manager involved in Defense RDT&E and systems acquisition, an awareness of the need for equivalent training of information program managers is just beginning to emerge. Consequently, long experience, extensive research, and wasteful reinvention of the wheel usually occur before a new Defense information center can serve effectively.

How can the new center avoid this lengthy learning period and expedite the development of expertise and a permanent corporate memory for conducting Defense information research and acquisition? One way is for information analysts to visit similar companies. Although the information needs of a company may uniquely represent its own operations and management philosophy, there will be commonality with many other Defense-oriented organizations. Gaining access to other companies might not be easy, but it is not impossible. Nonprofit or public institutions may be the most cooperative, but some for-profit contractors are willing to share their experiences as well. Marketing professionals, military and contractor information center managers, data managers, and others involved in acquiring, submitting, and distributing Defense information recognize the mutual benefits of networking with peers in other firms to share knowledge of legitimate routes into the complex world of Defense and government information.

Other sources of help include trade and marketing associations,[6] Defense-oriented trade publications, Defense/military Service publications, companies that specialize in information services, and consultants who have demonstrated knowledge and experience within your company's areas of interest. In addition, the Defense Systems Management College publishes useful guides, and many courses offered by Service-operated schools are open to contractors.[7] On occasion, as ways of doing business change or as issues arise, the Office of the Under Secretary of Defense Acquisition sponsors joint conferences with industry to air needs, problems, and solutions.[8] Although there is not a comprehensive educational program for the would-be Defense information professional, there is help for those who are determined.

Establishing and Operating the Information Center

Once the organization's information needs are understood, the information center can be established and operated.

- Facility location/ capitalization. The physical location of the center is as important as its hierarchical location. The closer and more conveniently available information services are to users, the more frequently they will be used. A location that is central to most users is best, but there will be much competition from other support units within the organization for these prime locations. Some of the disadvantages of a remote location can be offset by computer networking, but many information problems require that the user come to the center to conduct research in various interactive information resources and to take advantage of the staff's expertise. Thus, ease of access is essential to maintaining a viable relationship between providers and users of information. Indeed, without face-to-face dialogue with users and direct participation in the resolution of their information problems, the center cannot set direction and priorities for future resource and service development.

The center must create a pleasing, functional work environment. It should be clean, quiet, and able to provide clients with equipment that will help them use Defense information, which is rapidly being converted to digitized format. Capital procurement plans should include the acquisition of computer workstations, CD-ROM servers, internal/external network installations, scanning/facsimile equipment, and other means for modern information processing and communication. Online retrieval tools can be frontloaded with expert systems to create user-friendly environments that enable users to make the most of their time in the information center and reduce the number of information center staff needed to assist them.

- Information service delivery. Even though the information center may be conveniently located, requiring users to come to the center takes them away from their workplaces. To save on users' time, the center must have proactive methods to deliver information, even at the expense of magnifying the work of the information center staff. A balance must be achieved between user visits to the center and delivery of information products and services by the center through networked online services, publication of information newsletters, duplication of reference resources that are frequently used, and participation in the company's ongoing operation and planning reviews.

- Consulting services. The Defense information center acquires information resources that meet the company's needs for understanding the marketplace and for planning new business opportunities. In addition, it acquires management and technical information resources that can help the company complete contractual obligations in a timely and cost-effective manner that satisfies government standards for technical accuracy, completeness, and quality. If properly staffed, the information center can, in addition, provide direct consulting assistance in applying these broadly based information resources to the solution of a host of administrative, management, and technical problems. And by using its acquired knowledge of the marketplace, the center can help to ensure that strategic long range company plans are consistent with the future needs of potential government customers.

• Functional organization. The Defense information center should be structured organizationally to accomplish the following basic activities:

1. Acquisition of information resources
2. Promotion of services and delivery/distribution of information
3. Maintenance and control of information collection/databases
4. Administration
5. Management

The company's information needs and the size of the center will determine the organizational structure and the number of staff performing each activity. In smaller centers, one person may perform multiple activities; a larger information center may have specialists, for example, one person whose only job is to search databases--DoD, commercial, and in-house.

Fiscal Considerations

Whether the information center operates as an overhead expense within the company (expenses charged as general and administrative) or as a profit/loss center (expenses offset by reimbursements from charges to users), funding to meet the information needs of the organization will be limited and require the center to operate cost-effectively. Here are some tips to help the information center stay within budget while providing essential services.

• Prioritize company information needs. One of the most important tasks of the information director is the continual analysis and prioritization of the organization's information needs. This process also includes identifying the costs that are associated with meeting each need. From a matrix of priorities and costs, an optimum of information resources can be planned within a given budget.

• Making use of government-furnished information. Recognizing that Defense contractors must have access to certain information to fulfill contracts, the government makes millions of documents available to qualified contractors at minimal or no cost. Many of the repositories and centers[9] through which these documents can be obtained also provide information reference and consulting services. Government offices, agencies, and independent establishments are other sources of free or inexpensive information. Company Defense information centers must learn to navigate the government and military bureaucracy to obtain required information; otherwise, they may spend scarce funds buying needed information at much higher cost from commercial sources that profit from their inexperience. Of course, much information can be obtained only through appropriate channels and established need-to-know.[10]

• Operate on a cost-reimbursement basis. Although it may not be practical for every company to operate the information center on a cost-reimbursement basis (the company may be too small, the accounting system may not be able to support reimbursables, etc.), operating on a reimbursable basis has several advantages. First, it allows an information center to provide services that are paid for by the users. This serves to enhance user interest in the resources the center is obtaining and providing to the company. It also allows the information center to provide the company's top management with specific evidence of the value of the information center and helps justify continued or increased resources to support operations. Finally, it helps remove the information center from the pool of "fuzzy" overhead activities often targeted by line and program managers as adding additional expenses to production or services performed for customers.

• Continue to evaluate information resources for relevancy and currency. Maintenance and storage costs for information resources are similar to the inventory costs of a manufacturing company. Documents require shelf space or computer memory, or have other storage requirements. There is also an intangible cost associated with the time spent browsing through documents that are no longer current or relevant to the user. The information center must ensure that information collected and maintained is up to date, accurate, and appropriate to the company's needs.

Setting Priorities

The ultimate objective of the information center is to provide information. To furnish information to its users, the center must first obtain the information and prepare it for use. Once again, a parallel can be drawn between a manufacturing company and an information service organization. The manufacturing company seeks to build, maintain, and operate a plant that functions at an optimum level of output to minimize the amount of excess plant capacity and manufacturing capability. Similarly, the information center manager must prioritize staff efforts and operating funds to accomplish the five organizational activities identified above: acquiring information, delivering information, maintaining information, administration, and management. If too much emphasis is placed on information acquisition and maintenance, the collection of resources soon outgrows its use. If too much time is spent on promotion and delivery, the resources soon become outdated, and users who were initially attracted to the information center become disenchanted with the quality of resources and may not return. The activities of an information center vary according to the age of the center, the business cycle of the company, the turnover of information center staff, and other factors. Nevertheless, to adequately maintain a balanced approach, the information center should develop appropriate goals for each of the required activities and incorporate them into a comprehensive, long-range plan.

The Right Stuff

A modern mission-directed Defense information resource center is not a library. It depends on a library of resources and thus has many of the operational characteristics of a library, but it differs in having staff specialists who can effectively acquire and use military information resources that reflect the unique interests of the company. In addition to traditional librarians and information scientists, the center needs staff members with experience in the military/industrial complex to enable the center to use the latest information technology and communicate with the company's customers and with users of the information center from the perspective of subject area knowledge.

To further the organization's mission, each information specialist interacts with the others and with clients in a sophisticated network, illustrating Denning's[11] information processing paradigm that will "place people in a central role" that "will use networks of computers to nurture networks of people.... the new paradigm is not merely a library function. Libraries are important repositories for recorded and packaged knowledge but they do not support the critical function of networking. They will participate in the new paradigm but they will not dominate it."

Another benefit of the mission-directed information service is that it is responsive to the "soaring costs," as Dionne[12] has observed, that make it economically difficult to maintain comprehensive collections in the classic library tradition. Here, in contrast, the mission defines the collection and the networks it supports.

CONCLUSION: Looking Ahead and Planning for the Future

Information centers either grow or cease to exist, particularly those that operate on a cost-reimbursable basis! Growth depends on the center's success in maintaining a robust capability for information support and an aggressive promotion of services. The best information center managers will prioritize their staff activities and available funds to ensure that these two objectives are achieved.

ENDNOTES

1. See "Release of Acquisition Related Information," *Federal Register*, July 12, 1990, p. 28614.

2. Mickey Smith, "A Model of Human Communication," *IEEE Communications Magazine*, Vol. 26, February 1988, pp. 5-14.

3. For further information on MACIS, see Hattie T. Anderson, "In-house Information Management for Government Contractors," *Special Libraries*, Vol. 72, July 1981, pp. 224-232.

4. For a thoughtful discussion of this matter, see Brandt Allen, "Make Information Services Pay Its Way: Most Companies Can Use and Benefit from a Profit-Center Approach," *Mainframe Journal*, January 1989, pp. 79-80, 82, 84-86.

5. A recent article by Arlene Farber Sirkin, "Marketing Planning for Maximum Effectiveness," *Special Libraries*, Vol. 82, Winter 1991, pp. 1-6, illustrates the increasing importance of marketing to the success of the library/information center.

6. Examples of associations that address issues of defense information and contracting and that provide educational background include the American Defense Preparedness Association (ADPA), Electronic Industries Association (EIA), National Security Industrial Association (NSIA), Armed Forces Communications and Electronics Association (AFCEA), Special Libraries Association (SLA), and National Contract Management Association (NCMA).

7. DoD Catalog 5010.16-C, "Defense Management Education and Training," and the "Defense Systems Management College Catalog" provide two familiar lists of available courses. Other lists can be obtained from the Services' education and training commands.

8. The last of these, a "Joint Government-Industry Symposium on R&D Planning Information Management," was presented in 1988 by ADPA in cooperation with the Office of the Deputy Under Secretary of Defense (Research & Advanced Technology).

9. Important sources include the Defense Technical Information Center (DTIC), which casts an ever wider net to procure planning documents, scientific/technical reports, and other information needed by contractors; DTIC's sister service, the Defense Logistics Studies Information Exchange (DLSIE); the National Technical Information Service (NTIS); the Tri-Service Industry Information Centers, where R&D planning and requirements information is available for qualified industry representatives to review; the Government-Industry Data Exchange Program (GIDEP); Army, Navy, and Air Force publication centers; the Government Printing Office (GPO); and other repositories too numerous to mention.

10. DTIC's publication AD-A201600, "How to Get It--A Guide to Defense-Related Information Resources," revised December 1988, remains the single most valuable tool for identifying information sources and channels through which they are obtained.

11. Peter J. Denning, "The Science of Computing: A New Paradigm for Science," *American Scientist*, Vol. 75, November-December 1987, pp. 572-573.

12. Richard J. Dionne, "Science Libraries at a Crossroads," *American Scientist*, Vol. 76, May-June 1988, pp. 268-272.

APPLYING PROCESS CONTROL TECHNIQUES TO DOD PROFIT NEGOTIATIONS

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ABSTRACT

This paper attempts to define the profit negotiation process, measure the process output, and analyze why the output may deviate from the expected result. The profit negotiation process is defined using four distinct steps from Profit Policy to Negotiated Profit. It is proposed that the Weighted Guidelines control the transition between each of the steps. Based on a finding that, for each individual contract, the possible profits generated by Weighted Guidelines are normally distributed, the profit "Z" score is proposed as an appropriate process metric. The profit "Z" score is used to measure the results of individual profit negotiations as well as the DoD profit process.

Using the profit "Z" score technique, it was found that the profits reported in fiscal year 1989 through DoD's profit reporting system were both higher and more dispersed than expected. This result is analyzed and the findings from the 1984 Defense Financial and Investment Review Personnel Survey are explored as a possible explanation for the anomaly.

INTRODUCTION

The DoD Profit Process. The profit negotiation process begins with the Department of Defense (DoD) profit policy which is directed to the contracting officers in the form of the Weighted Guidelines Application (DD Form 1547). Prior to negotiations, contracting officers use the Weighted Guidelines to calculate a profit objective. During the negotiation, the parties to the contract agree on the cost elements and then the appropriate profit. At the conclusion of negotiations, the contracting officer reports both the objective and negotiated profits back to DOD.

The Problems. This paper will address two problems with the current profit process. First, contracting officers receive little feedback from the policy makers on how their profits compare to DoD expectations. Second, there does not appear to be a comprehensive method of assessing the reported profits to determine how well field contracting activities are implementing DoD's profit policy.

The Solution. This paper addresses both problems using an indicator, known as the profit "Z" score. The profit "Z" score normalizes all the variations of contracts addressed by the weighted guidelines and provides immediate feedback to the contracting officer on how the negotiated profit amount compares to the DoD expected profit. The compiled profit "Z" scores can also be used on the DoD level to indicate whether or not the profit negotiation process is producing the desired output. In order to illustrate the use of the profit "Z" score for assessing reported profits, the Fiscal Year 1989 profit process output is analyzed and the results are discussed.

PROCESS DEFINED

The DoD Profit Negotiation Process. The four steps in the DoD Profit Negotiation Process are shown in Figure 1. The DoD profit negotiation process begins with the profit policy (Step 1) promulgated by DOD and is directed to the contracting officers in the form of the Weighted Guidelines Profit Analysis Method (Step 2). The Weighted Guidelines method is DoD's structured approach for rewarding risk, motivating efficient and quality performance, and stimulating capital investment. The profit awarded is based upon a weighted combination of four profit factors: performance risk, contract type risk, working capital investment, and facility capital investment. The DoD Federal

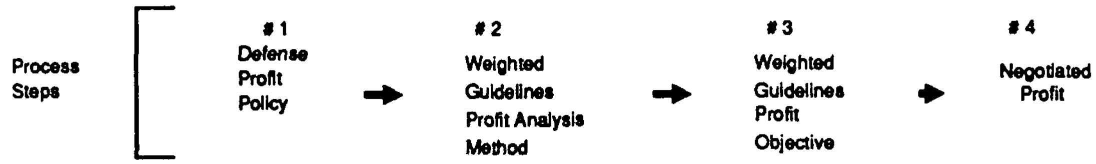

Figure 1. The Defense Profit Negotiation Process

Acquisition Regulation (DFAR) provides a range of profit factor values used to weight the costs for each of the four profit factors. The median value in the range is the normal value which is defined as the expected profit assignment where average conditions exist when compared to all goods and services acquired by DoD. Prior to negotiation, the contracting officer selects a value from the range of profit factor values and applies it to the cost objective for each factor to arrive at an objective profit (Step 3). Subsequent to the objective profit, the parties involved negotiate and agree on an appropriate cost and profit for the effort contemplated. This appropriate profit is identified as the negotiated profit (Step 4) in Figure 1.

The Last Step. It is not clear if the objective profit or the negotiated profit is the last step in the process of interest to DoD. The DFAR states that the Weighted Guidelines apply only to the Objective Profit (2:215.903). This would seem to imply that the objective profit is the last step in the process of interest and negotiated profit is a result of some independent process. However, funds are obligated based on negotiated profit, not objective profit, therefore some connection must have been intended between the guidelines for objective profit and the negotiated profit. The connection is that the final negotiated profit must be based on the four profit factors recognized by DoD (2:215.971). These four profit factors are also the basis for the Weighted Guidelines. Given that the contracting officer was required to use weighted guidelines to arrive at an objective profit prior to negotiations, and given that the negotiated profit must be a result of the four factors used by Weighted Guidelines to arrive at a profit objective, then it can be safely stated that Weighted Guidelines are used implicitly to arrive at a negotiated profit. Implicitly means that while the Weighted Guidelines are not negotiated element by element, the prior positions of both parties, which were originally justified using Weighted Guidelines, are altered within the framework of the four required factors

Process Summary. It is proposed then that negotiated profit is the last step in a continuous process from profit policy to negotiated profit and the Weighted Guidelines are controlling the transition between each step in the process. Figure 2 illustrates the profit negotiation process including the assumed mechanisms which control the transition between the four steps.

PROVIDING FEEDBACK

A "Z" score For Individual Contracts. When the contracting officer has reached the

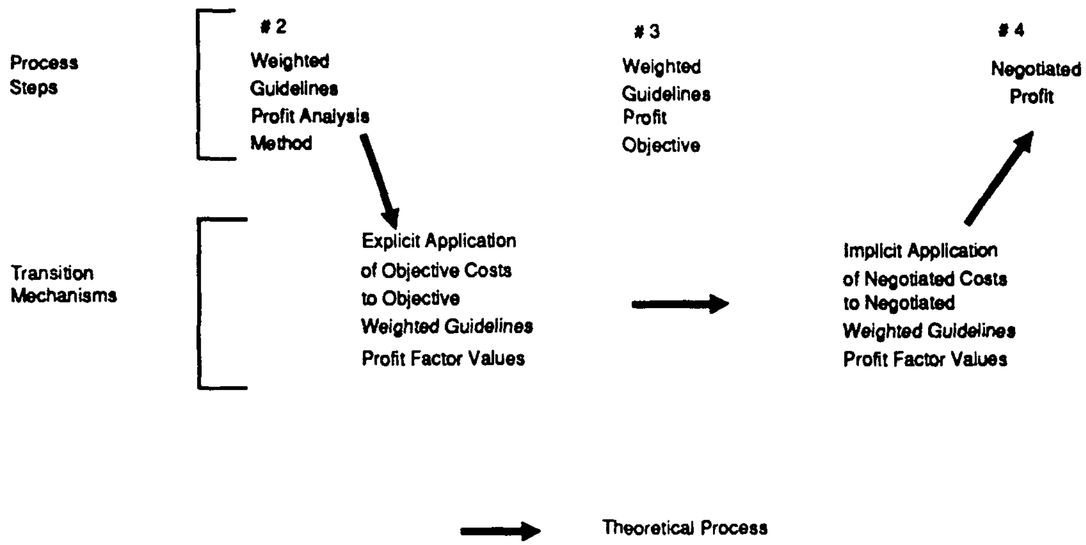

Figure 2. The Defense Profit Negotiation Process, with Theoretical Transition Mechanisms

negotiated profit step there is no feedback from policy makers to define how that dollar amount compares to the DoD expected profit when average conditions exist for contracts with similar characteristics. The "Z" score for individual contracts provides the contracting officer with that feedback. In statistics, the letter "Z" is used to represent a random variable with a mean of zero and a variance of one. Traditionally, "Z" represents the standardized from of the normal distribution. In the negotiation process, the "Z" score is a way of measuring variation in a population of profits that is normally distributed. With a single number the "Z" score communicates the profit's relative position in the distribution of profits possible using weighted guidelines. In order to use the profit "Z" score, it first had to be determined that the population of possible profits generated through the weighted guidelines was normally distributed. Using samples from the database of contracts reported for FY 1989, it was found that for each individual contract, a frequency diagram of possible profits resulting from all combinations of profit factor values has a normal distribution and the mean/median of this distribution is the profit resulting from the normal profit factor values (1:88). The negotiated profit is a member of the population of profits forming this normal distribution and can be described in terms of the number of standard deviations from the mean. If the negotiated profit is measured in terms of standard deviations about the mean, the probability of that profit amount occurring is described by Figure 3. As would be expected with a normal distribution, profit amounts extending on either side of the mean have an increasingly smaller probability of occurring due to normal variation. The location of any particular profit amount along the horizontal axis can be described in terms of the number of standard deviations from the mean or the

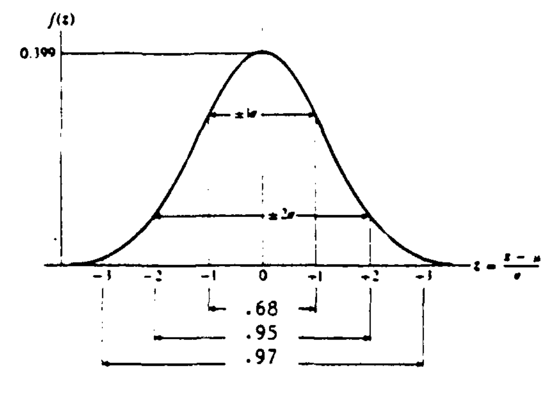

Figure 3. Standardized Normal Probability Distribution

"Z" score. The greater the number of standard deviations from the mean, the more unusual its occurrence. For example, less than five out of 100 contracts would be expected more than two standard deviation from the mean, and less than three out of 100 would be expected three standard deviations from the mean.

Implementation. This measure, if included in Weighted Guidelines, would give the contracting officer feedback on how the negotiated profit compares to what was expected by the DoD policy makers. The "Z" score calculation can be included as a sub routine within the automated weighted guideline packages available for micro-computers. When the contracting officer sees that the negotiated profit is several standard deviations from the mean, the contracting officer can reassess his selection of factors to assure that the conditions of the contract are as unique as the "Z" score indicates.

THE PROCESS INDICATOR

A "Z" Score for the Process. When the profits obtained through the profit reporting system are reduced to "Z" scores as described in the previous section, these individual profit "Z" scores can be arranged to form a distribution which reveals information about the nature of the process output. The multitude of Weighted Guideline allowable profit factors and cost combinations result in a unique normal probability distribution for every contract. Because normal distributions are described by their two parameters, the mean and the standard deviation, each profit distribution will have a unique mean and standard deviation.

Implementation. The "Z" score effectively transforms each unique profit distribution into a standard normal profit distribution with a mean of zero and a standard deviation of one. Theoretically, just as it would be expected that a random selection of one member from many independent and identically distributed populations would result in a new population with parameters identical to its constituents; it would be expected that a random selection of a single profit amount ("Z" score which represents negotiated profit amount) from each of the individual contract standard normal probability distributions would itself result in a standard normal distribution. Theoretically, all reported profit "Z" scores should form a normal distribution with a mean of zero and a standard deviation of one. Empirically, however, when the results of the FY 1989 reported profit "Z" scores were placed in a frequency diagram, the resulting distribution was normally distributed but with a mean of .24 and a standard deviation of 1.5 (1:85). This result indicates that the process is producing prof both higher than the expected average and more dispersed than expected.

DISCUSSION OF RESULTS

Re ons for Differences. There are two ex nations why the DOD profit negotiation process does not yield results expected. The first explanation is that the process is correct but our expected result is in error, the second explanation is that the process is not defined correctly.

Expected Result in Error. The expected result is based upon the premise that the average contract is expected to be assigned the normal profit factor value. The DFAR contains the following definition of normal value. "A normal value and designated range have been established for each profit factor. The normal value is the expected profit assignment where average conditions exist when compared to all goods and services acquired by DoD" (2:215.970).

The Exceptions. Having stated this rule, the DFAR then provides three exceptions where, for the particular application noted, the weighted guidelines instructions will not result in the normal value being the expected profit assignment. The first exception for Time-and-Material contracts (2:215.9-8) could cause the expected profit assignment for cost-plus-fixed-fee contracts to be higher than the normal value. The second exception for Fixed Price Contracts with Redeterminable Provisions could cause the expected profit assignment for fixed-price-incentive contracts to be lower than the normal value. The third exception for Foreign Military Sales (FMS) provisions (2:215.9-8) could cause any type of contract with FMS provisions to result in a higher than normal profit value. For the purpose of this research, it was assumed that these three exceptions would not affect the premise that the average contract is expected to be assigned the normal profit factor value. That assumption may have caused the error.

Process Not Defined Correctly. It is possible that the "Theoretical" process shown in Figure 2 is not correct. Specifically, it is possible that Weighted Guidelines are not the controlling transition mechanism between steps but that other variables influence the outcome. Other possible variables, some of which were highlighted by the 1984 Defense Financial and Investment Review, are shown in Figure 4 as the "Actual" process and described below.

Other Variables Steps 2-3. The transition between Weighted Guidelines Method (Step 2) and Weighted Guidelines Profit Objective (Step 3) may be influenced by variables other than Weighted Guidelines. Prior to negotiation, the Defense Federal Acquisition Regulation requires contracting officers to calculate a Weighted Guideline profit objective by applying the objective costs to the appropriate weighted guideline profit factor values (2:215:903). This is the transition mechanism which is assumed to govern the relationship between steps 2 and 3. There are three other variables which may also impact on the transition between these two steps.

Accuracy. Although the guidelines are well written, the contracting officer may not be completely accurate in following the Weighted Guideline instructions. It is possible that the accuracy with which the contracting officer follows the Weighted Guidelines could increase of decrease the expected objective profit.

Interpretation. The contracting officer's interpretation of the subjective elements based on individual experience may affect the profit objective. Interpretation differs from accuracy in that accuracy identifies the ability of the contracting officer to select the correct range of profit factor values permitted by weighted guidelines. Interpretation identifies the basis on which each contracting officer selects a profit factor value from the allowable range. The guidelines state that the contracting officer should select a value from the range of profit factor values based on whether the contract conditions are above normal, normal, or below normal. The guidelines define normal as the "expected profit assignment where average conditions exist when compared to all goods and services acquired by DoD." (2:215.9-3). For each profit factor the Weighted Guideline instructions give a further explanation of below normal, normal, and above normal conditions; however, it is possible that the contracting officer will base normal on his own experience rather than the standard. The contracting officers interpretation of the subjective elements of weighted guidelines could increase or decrease the expected objective profit.

Management Direction. Local management direction may affect the profit objective. The personnel survey portion of the 1986 Defense Financial and Investment Review reported that "Over 55 percent of all respondents agree that the profit/fee

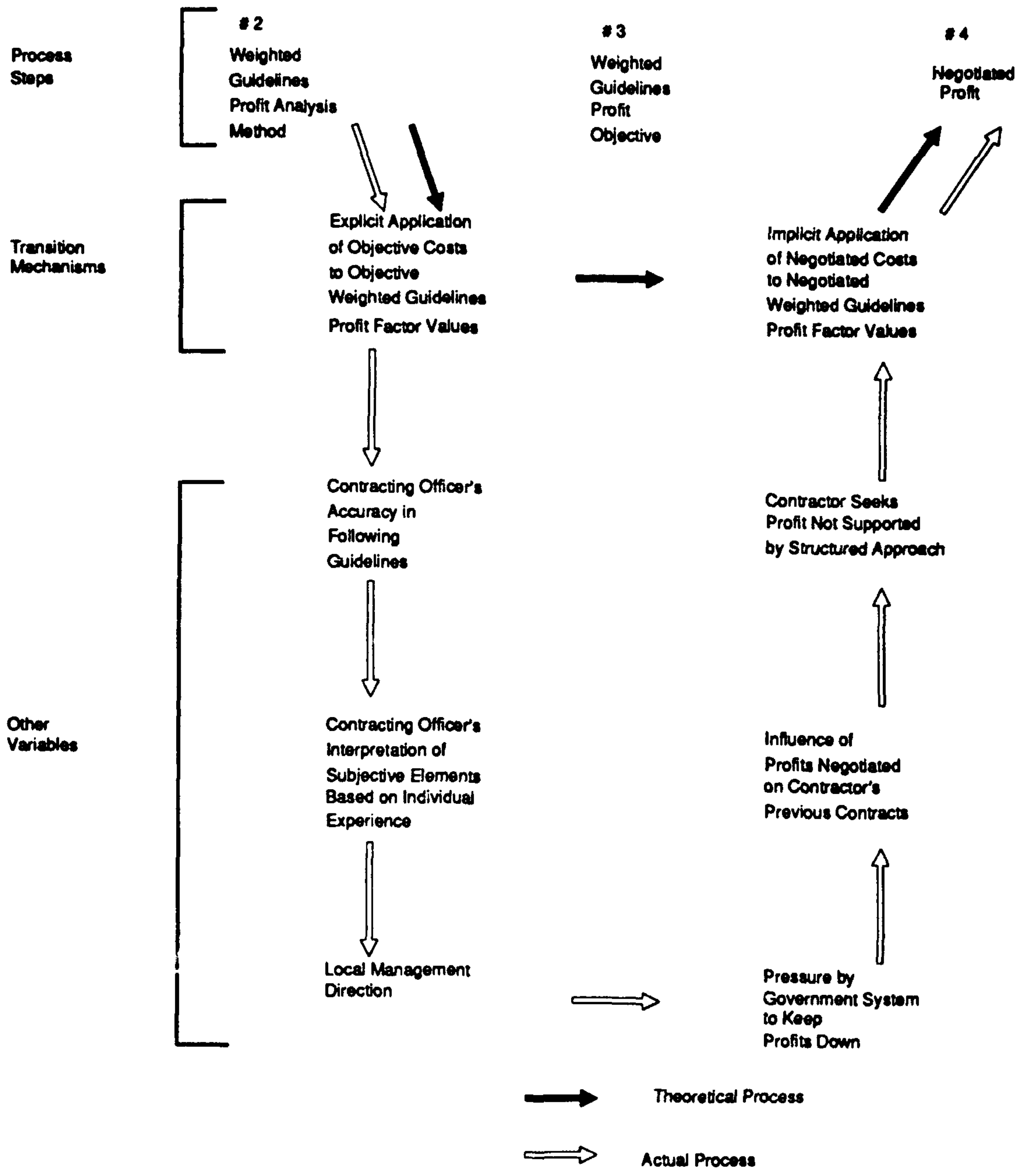

Figure 4. The Defense Profit Negotiation Process with Theoretical Transition Mechanisms and Other Variables

objective is often dictated by management regardless of the Weighted Guideline computation" (3:90). Local management direction may either increase or decrease the expected objective profit.

Other Variables Steps 3-4. The transition between Weighted Guidelines Profit Objective (Step 3) and Negotiated Profit (Step 4) may also be influenced by variables other than Weighted Guidelines. The assumed mechanism operating between steps 3 and 4 is the implicit application of negotiated costs to negotiated weighted guideline profit factor values. There are three other variables which may have an affect on negotiated profit.

Contractor Approach. The method of analysis used by the contractor may affect the negotiated profit. The DoD recognizes four components of profit: performance risk, contract type risk, working capital investment, and facilities capital employed. These factors are the basis for the Weighted Guideline method used by contracting officers. Contractors, on the other hand, are not bound by Weighted Guidelines and may seek to negotiate a profit not supported by this particular structured approach. Contractors may quantify the components using some other method and target a company required internal rate of return. In the Defense Financial and Investment Review personnel survey, "Ninety-One percent (91%) of all respondents agreed that regardless of Weighted Guidelines, contractors are out for a specific profit return on each contract" (3:99). A differing contractor approach can either increase or decrease the expected Negotiated Profit.

Profits of Previous Contracts. Contracting officers may be influenced by precedents set by previous negotiations with the contractor on similar contracts. In the Defense Financial and Investment Review personnel survey, "Seventy-one percent (71%) of all respondents agreed that negotiated profit rates are more closely related to profit rates negotiated with a particular contractor on previous contracts than they are to the Weighted Guideline objective" (3:82). Previously negotiated rates may increase or decrease the expected negotiated profit.

Pressure within the System. The process of negotiation may be viewed by some government contract personnel as a zero sum game where higher profits translate into a loss of value to the government. This perception may cause pressure on contracting officers to keep profits down. The Defense Financial and Investment Review reported "Seventy-Five percent (75%) of all respondents agreed that the system puts a lot of pressure on contracting officers to keep profits down" (3:92). This perception may cause a decrease in the expected negotiated profit.

CONCLUSION

The DoD profit negotiation process consists of four steps connected by the Weighted Guidelines Profit Analysis Method. Although profit data is currently collected through the DoD profit reporting system, there is little feedback to contracting officers from policy makers on how profits compare to DoD expectations. This may be a function of the lack of a single indicator which reveals information about the process output. The "Z" score is an indicator which can be incorporated into the Weighted Guideline and readily computed by the microcomputer weighted guideline programs. The individual contract "Z" score provides feedback to the contracting officer on how his judgement of the elements of profit compare to the DOD standard(the expected profit where average conditions exist.). The Individual profit "Z" scores when viewed collectively provides a one look indicator of how the results of the process compare to the expected process output. When the results of the Fiscal Year 1989 profit report were analyzed, it was found that the reported profits were both higher and more widely dispersed than expected. This discrepancy could be attributable to an incorrect judgement of the expected profit or to additional variables which impact the process. In any case, the ability to quantify a process output is the first step in process improvement.

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FACIAL REPRESENTATION OF COST/SCHEDULE PERFORMANCE DATA

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ABSTRACT

Using schematic faces to represent information may facilitate analysis of cost/schedule performance data. The method employs a technique of matching certain facial characteristics with specific variables of the database. As the value of the variable changes, so does the appearance of the face. Presumably, these facial changes enable an analyst to recognize relationships and trends more effectively than afforded by more traditional presentation modes. In this study, the effectiveness of tabular and facial presentation modes were compared in a controlled experiment using cost/schedule performance data. Results showed that tabular presentation was more effective. However, with some training the use of faces may be an effective decision support tool.

INTRODUCTION

The use of schematic faces is a method of analyzing and presenting data using multidimensional graphics. Chernoff [2,3] suggested that human skills at pattern recognition may be exploited with the use of faces drawn to represent multivariate data. For example, several key indicators may be linked to specific facial characteristics, such as the shape of the eyes, mouth, and nose. As these indicators change, so does the face. According to Chernoff [2:361], the resulting face may allow the investigator to see how all the indicators fit and move together. Traditional graphs may not reveal interrelationships among the variables as efficiently. Accordingly, the use of faces to represent multivariate data may make analysis of such data easier, faster, and more accurate [5].

The use of Chernoff faces to analyze financial information has been investigated by various researchers with mixed results. Moriarity [11], for example, concluded that students were able to more quickly and accurately predict the bankruptcy of 22 firms when using facial displays instead of tabular data. Stock and Watson [12] had similar results with students predicting changes in bond ratings. MacKay and Villarreal [9] reported conflicting results, and suggested that the effectiveness of the facial representation of multivariate data depends on individual differences (e.g., experience, training, decision style, gender) and the specific decision task. Overall, the researchers are positive about the potential of the faces as decision support aids and encourage further research [4].

This research was the first to investigate the use of Chernoff faces with cost/schedule performance data. Cost/schedule performance data are typically required of defense contractors on monthly Cost Performance Reports and Cost/Schedule Performance Reports. Key data elements include Budgeted Cost of Work Performed (BCWP), Budgeted Cost of Work Scheduled (BCWS), Actual Cost of Work Performed (ACWP), Budget at Completion (BAC), and Estimate at Completion (EAC). Analysts typically generate ratios of these data elements to create information about the cost and schedule status of the contract. Given the tabular format of these performance reports and the complex relationships between the data elements and key performance indices, the use of Chernoff faces may be an effective tool to help analysts assess cost and schedule progress.

METHODOLOGY

Hypothesis. The general hypothesis tested was that the facial representation of cost/schedule data will result in more effective decisions than when tabular data are used. Decision effectiveness was defined as decision accuracy divided by decision speed. The sensitivity of the results to participant experience, learning, and training were also investigated by using a post-test questionnaire.

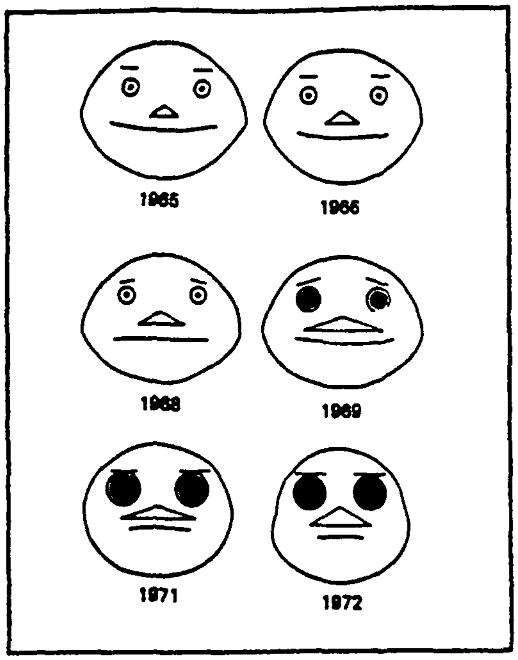
Test Instrument. Cost/schedule performance data for eight contracts were fabricated and presented to the participants in both tabular and facial modes from a microcomputer. Each participant randomly viewed four data sets in tabular and four data sets in facial modes. After viewing each data set, the participants responded to questions presented on the computer screen designed to test their ability to analyze and make correct decisions based on the data presented. The students were not allowed to return to the screen previously viewed to answer a question. Response times and answers were recorded on floppy disks.

Prior research with Chernoff faces has utilized software written for a mainframe and presented to the test subjects on paper [6]. A sample of these faces is illustrated in Figure 1. To more meaningfully test the effectiveness of the faces as a decision support tool and enhance external validity, a personal computer was considered a more appropriate platform. Software to draw the faces, ask the questions, record the responses, and analyze the results was developed using Microsoft QuickBasic [10], a programming language for a MS-DOS personal computer. Figure 2 illustrates faces drawn by this software.

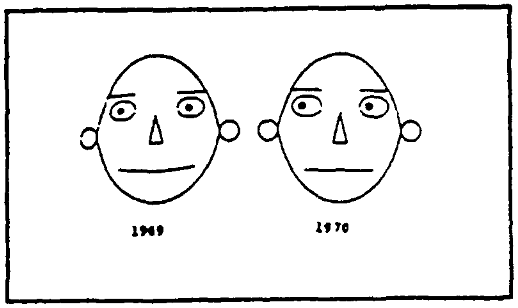
In the absence of any theory, and consistent with prior research, the choice of cost/schedule indicators and their assignment to specific facial features was strictly subjective. The indicator/facial pairings are shown in Table I. For a description of these and other cost/schedule indicators see *Guide to Analysis of Contractor Data* [1].

Test Subjects. The experiment was administered to groups of 2 to 12 students attending courses at the Air Force Institute of Technology. In all, 50 students participated in the experiment. The students received five minutes of oral explanation dealing with the operation of the computer and the software. Each student was also given an information sheet listing some key definitions, the indicator-feature pairings, and three faces and corresponding data sets depicting good, bad, and neutral performance. The students were generally familiar with the cost/schedule performance terminology and indicators used.

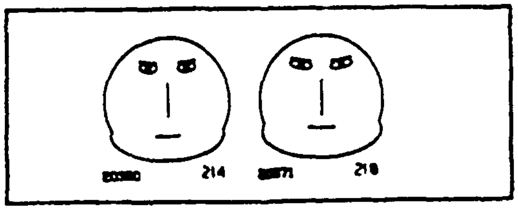
Hypothesis Testing. The hypotheses were tested using either a paired t test or the Wilcoxon Sign-Rank Test. The type of test used depended on the distribution of the response data. The Wilk-Shapiro test was used to determine whether the data were normally distributed. If normally distributed, the parametric paired t-test was used; otherwise, the Wilcoxon Sign-Rank test was used. All tests were conducted using the .05 significance level.



A. Moriarity and Roach
from Libby (8:119)

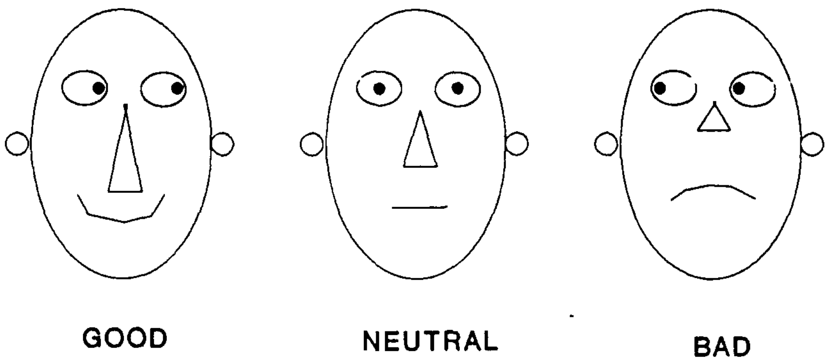


B. Moriarity (11:209)



C. Chernoff (2:364)

Figure 1. Examples of Faces in Literature.



	BCWS	BCWP	ACWP	SV	CV	SPI	CPI
GOOD	2000	4000	2000	2000	2000	2.000	2.000
NEUTRAL	4000	4000	4000	0	0	1.000	1.000
BAD	10000	4000	7000	-6000	-3000	0.400	0.571

Figure 2. Facial Representation of Cost/Schedule Performance Data

TABLE I

Performance Indicators and Facial Features

Performance Indicator	Facial Feature
Cost Variance (CV)	Eyebrow Position
Shedule Variance (SV)	Pupil Position
Cost Performance Index (CPI)	Curvature of Mouth
Schedule Performance Index (SPI)	Nose Length

TABLE II

Presentation Mode Results

	Chernoff faces	Tabular data	Significance (P value)
Average time (seconds)	368.7	209.7	.0000
Average number correct	7.7	10.2	.0000
Effectiveness	84.1	188.1	.0000

RESULTS

Decision Speed. Response times were recorded by the computer for each student. The mean times required to answer questions using the faces and tabular formats were 369 and 210 seconds, respectively (Table II). This difference was significant the .05 level. The results indicate that the students took significantly less time to answer the questions when cost/schedule performance data were presented in tabular form.

Test for Decision Accuracy. Individuals were asked a total of 24 questions in the experiment. Half of the questions involved data presented in the form of faces and the other half involved data presented in tabular form. The mean number of correct answers for face format questions was 7.7 and the mean number of correct answers for tabular format questions was 10.17. The difference was significant at the .05 level. The results indicate that the students answered significantly more questions correctly when the data were presented in tabular form.

Test for Decision Making Effectiveness. For this study, decision effectiveness was defined as a function of both decision speed and decision accuracy. Decision effectiveness is equal to decision accuracy divided by decision speed (in hours). The mean value for decision effectiveness when the faces format was used was 84.05 correct answers per hour. The mean value for decision effectiveness when the tabular format was used was 188.10 correct answers per hour. The difference was significant at the .05 level. The results indicate that the use of faces do not lead to more effective decisions.

ANALYSIS

MacKay and Villarreal [9] have suggested that individual differences and decision task are potential mitigating factors. Accordingly, the results were analyzed for sensitivity to differences in decision problem, confidence, training, experience.

Trend detection. Graphical methods have been used effectively to aid the decision maker in the detection of trends in data.

A few of the questions in the experiment were designed to measure the students' ability to detect trends in the cost/schedule performance data. Based on the mean results, tables resulted in significantly faster, more accurate, and more effective decisions. Faces did not produce more effective decisions with respect to trend determination.

Decision Confidence. To test for decision confidence, the students were asked to respond to six statements dealing with their perceived confidence in answering the experiment questions, and their confidence in the mode of presentation (based on perceived ease of use and accuracy). Three statements dealt with the use of faces and the other three dealt with the use of faces. Responses to the statements were based on a five point Likert scale, with five being the most confident, and one the least confident. The results indicated that the participants felt significantly less confident making decisions using faces than they did when making decisions using tables.

To measure if individuals would use the faces technique in their jobs they were asked to respond to the statement "If I had the opportunity I would use the faces format my job." Overall, forty percent of the students would consider the use of faces in their jobs.

Experience. After the experiment, the students were asked to list the amount of experience they had with cost/schedule performance data. To evaluate the influence of experience on the results, the scores for decision effectiveness of those having less than one year experience were compared with the scores of those having more than one year experience. The data indicated that the level of cost/schedule performance experience did not have a significant influence on decision making effectiveness when faces were used.

Learning. Because the eight data sets used in the experiment were distributed so that each data set appeared in the top half (first four data sets) as many times as it appeared in the bottom half (last four data sets), the two halfs could be compared to measure potential learning. Decision making effectiveness was significantly greater during the second half. Therefore, learning occurred during the experiment.

Training. To evaluate the effect of training, a second experiment was administered where students were given five minutes of oral instruction on how to analyze cost/schedule performance data using the faces. A comparison of experimental results between the second and first experiments was then accomplished. The comparisons were limited to cases involving the faces presentation mode only. Overall, results indicated that the use of the five minute teaching session resulted in significantly more effective decision making. (The results indicated that the application of the five minute teaching resulted in significantly faster but not significantly more accurate decisions.) Results also indicated that those individuals who received training on the use of the faces were more confident when making decisions based on data presented as faces than those who did not receive the training. Sixty percent of the students who received the training would consider using the faces format in their job.

CONCLUSION

This research showed that an individual using Chernoff faces for the first time to analyze cost/schedule performance data would probably have difficulty making decisions based on those faces. The individual would perform better using tabular data. Further research revealed that an individual who received training in the use of faces would make more effective decisions than one who received no training. The potential exists for Chernoff faces to become an effective decision support tool. Two factors that may facilitate this are training and experience.

One possible use of Chernoff faces may be as a companion to tabular data. The faces software developed for this experiment can display the faces and the corresponding data on the same screen. It is not clear if displaying faces with tabular data will improve decision effectiveness. Perhaps future research can test this hypothesis.

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GRAPHS THAT LIE--AN EXPERIMENT

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ABSTRACT

Business graphics software affords the user with powerful capabilities to manipulate the type and format of a graph. While manipulation can be informative, it may also result in a graph that misrepresents the underlying data. Accordingly, criteria for high-integrity graphs have been suggested. Presumably, graphs that violate these criteria may mislead decision makers. To test this hypothesis, graphs were collected from contractor and government sources involved in Cost/Schedule performance reporting. Some of these graphs were found to violate the criteria. In a controlled experiment, a series of potentially misleading graphs were presented to students attending cost/schedule performance courses. The students were misled by graphs that violated the criteria. The prudent analyst and decision maker should be wary of the powerful formatting capabilities of business graphics software. Graph type and format are variables that can influence the decision maker's ability to comprehend problems and make effective decisions [3].

INTRODUCTION

Business graphics software is becoming an increasingly popular tool of analysts and decision makers [6]. When properly prepared, graphs can reduce the information overload problem and enhance a manager's understanding of the data; when improperly prepared, graphs can be extremely misleading [10]. For government contractors working on a project in which Cost/Schedule Control Systems Criteria (C/SCSC) are mandated, cost/schedule performance data are usually reported on monthly Cost Performance Reports (CPRs). Given the complexity and volume of the reporting requirement, graphs of CPR data are commonly used by contractor and government personnel to summarize and assess the status of their projects. In some cases, contractors are supplementing the CPR with graphs. In other cases, government analysts are placing CPR data into electronic spreadsheets and generating graphs using the powerful formatting capabilities embedded in the software.

While the use of graphs in this context is completely appropriate, there is a potentially serious problem afforded by this new capability: graphs can be misleading. With the use of business graphics software the user can drastically alter the appearance of a graph by simple manipulation of graphical type (e.g., bar, line, area, pie, etc.) and format (e.g., axis, scale, order, label, dimension, range, etc.). In the process of experimenting with these capabilities, the user may unwittingly create a false impression of the underlying data through an improperly constructed graph.

Many authors have proposed standards for good graphsmanship. The first standards were proposed by the Joint Committee on Standards for Graphic Representation in 1915. Over the years, many other guidelines, or criteria, have been developed [2, 11]. Simplicity seems to be the key behind many criteria, as an overly "busy" chart may disinterest or even confuse the reader, leaving the true message of the data untold.

Presumably, if these criteria are followed, the resulting graphs are less likely to mislead decision makers. However, there is little empirical evidence demonstrating the utility of these criteria. Therefore, an experiment was developed to test the hypothesis that graphs which violate high-integrity criteria are misleading.

METHODOLOGY

Criteria for high-integrity graphs were identified from an extensive literature survey of style guides, graphics handbooks, and human factors research. Graphs typically used in CPR analysis were collected from a survey of contractors and analysts involved in CPR reporting. From this database, six representative graphs and a criterion judged most likely to affect each graph were selected for the experiment. The graphs were prepared using the graphics routines of a popular electronic spreadsheet, and presented to the students on paper.

A convenience sample of 63 students attending professional continuing education courses involving cost/schedule performance analysis participated in the experiment. All of the students were familiar with the terminology and graphs used in the experiment, and were randomly assigned to control and experimental groups.

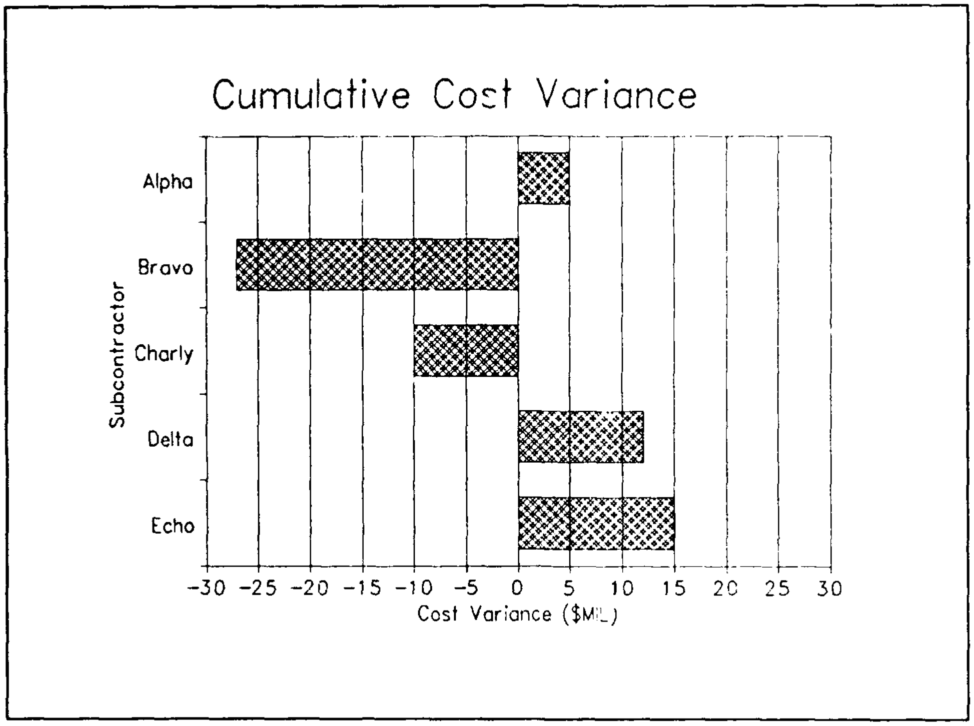
A "pretest-posttest control group design" [1] was used to test the hypothesis that graphs which violated the criteria were misleading. In the pretest, both groups were randomly exposed to the same graphs. None of the graphs in the pretest violated the criteria. In the posttest, the experimental group was randomly exposed to graphs which violated the criteria while the control group was randomly exposed to the same graphs but which did not violate the criteria.

After viewing each graph, a conclusion corresponding to the graph was presented. The students were asked to agree or disagree with the conclusion by checking the appropriate box on their paper. The students were not allowed to review the graph after reading the conclusion. A correct answer did not always require the students to agree with the conclusion. Two-by-two contingency tables and the Yates' Chi Square statistic were used to test for any between-group difference in the scores. If there was a statistically significant difference in the between-group scores, the graph was defined as misleading.

Figures 1 through 6 compare the high-integrity and misleading graphs used in the posttest. The conclusions corresponding to each graph is also presented. In each figure, the graph on the bottom was deliberately constructed to violate a selected high-integrity criterion and presented to the experimental group. The graph on the top was presented to the control group. A brief description of each graph follows:

Figure 1. The criterion tested involves the order of the data presented on the horizontal axis. Negative data are usually presented to the left of positive data on the horizontal axis (or underneath positive data on the vertical axis). In the bottom graph this convention is reversed on the horizontal axis, with the potentially misleading impression that Contractor E has the largest unfavorable cost variance.

Figure 2. In area graphs the stratum with the least variability should be on the bottom. The rule to remember when reading area graphs is to measure each stratum from the one immediately below



Subcontractor Bravo has the largest unfavorable cost variance.

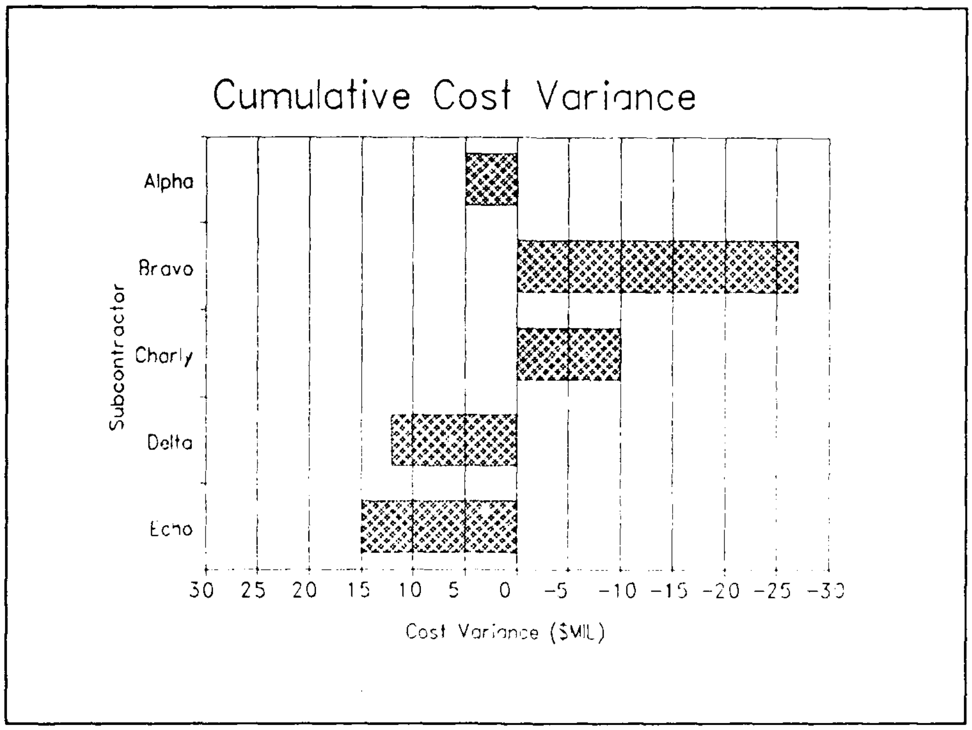
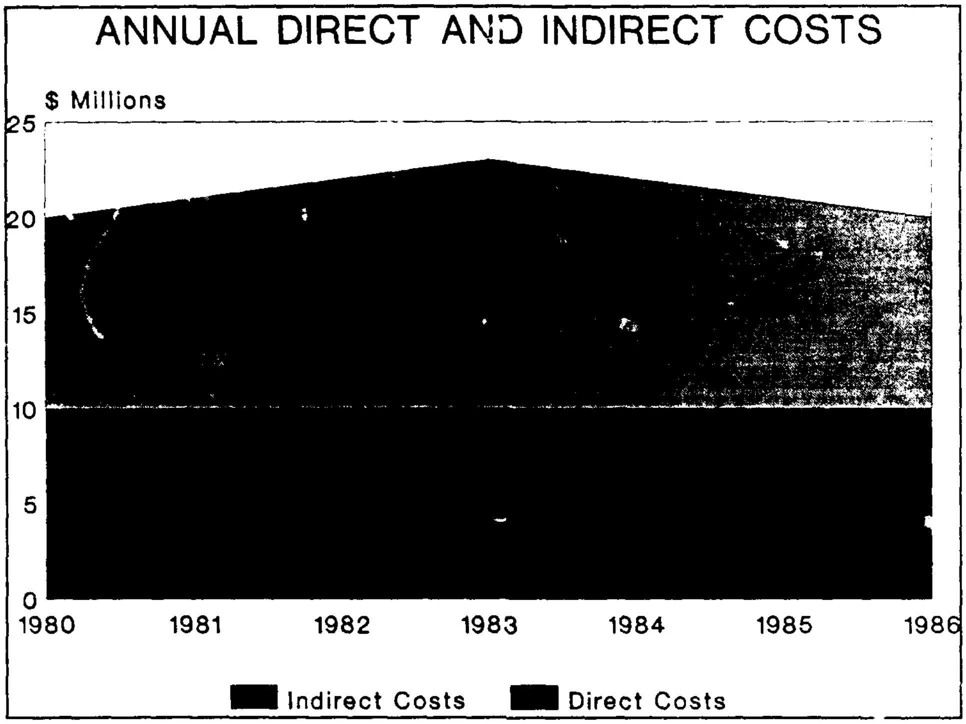


Figure 1. Horizontal bar chart



Indirect costs have been the same each year.

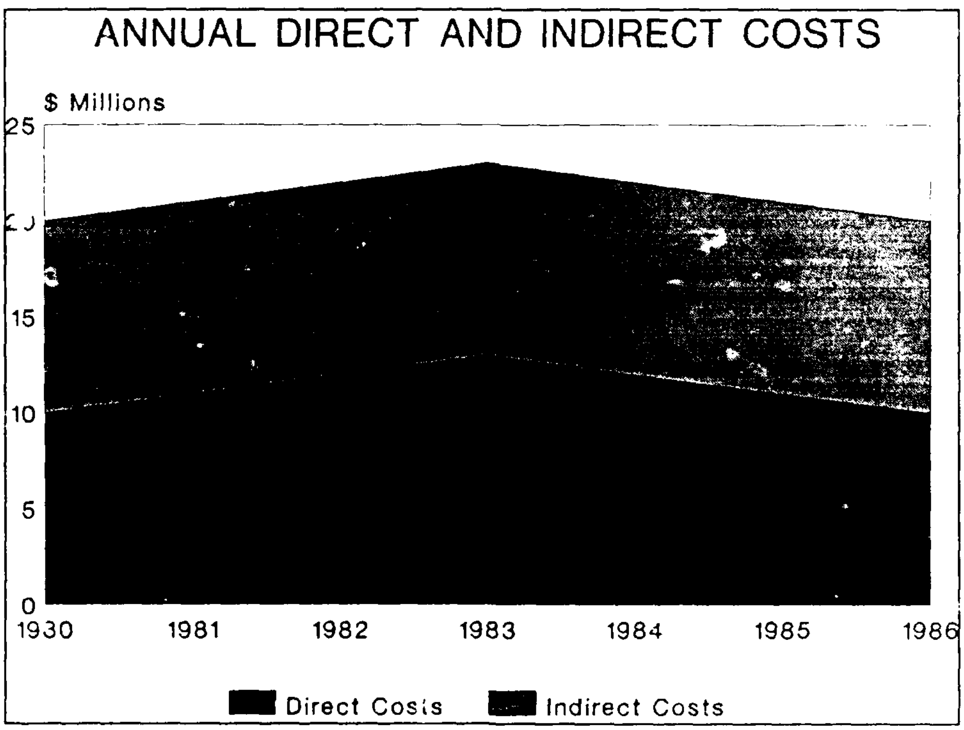


Figure 2 Area Chart

it, not from zero. The top graph correctly follows this criterion; the bottom graph violates it.

Figure 3. According to Tufte, "the number of information carrying dimensions should not exceed the number of dimensions in the data" [11:77]. As shown in this figure, by substituting volumes in place of linear magnitudes, a misleading graph may be created.

Figure 4. The criterion tested in this figure involves the expected order of data presented on the vertical axis. By reversing the normal order of the vertical axis, an unfavorable trend may appear favorable to the casual observer.

Figure 5. The criterion tested in this graph involves the order of time (years) presented on the horizontal axis. Reading the bottom graph from right to left would convey the correct impression that both cost and schedule variances are growing worse, but people are generally conditioned to read time series charts from left to right. Reversing the order of time on the bottom graph creates the false impression of favorable trends.

Figure 6. Labeling can be very useful in reading and understanding graphs. In the top of graph, the labeling may actually help the decision maker interpret an unusual graph. If the labeling is incorrect, however, a decision maker may be misled.

RESULTS

As indicated in Table I, the hypothesis was generally confirmed. With the exception of the bottom graph in Figure 1, graphs that violated selected high-integrity criteria were misleading. Because the Figures 1 and 5 essentially tested the same criterion, it is suspected that the specific nature of a graph is a confounding variable in the experiment. These results are consistent with those reported by Taylor [10]. Although Taylor's test subjects were financial officers and CPAs, and her graphs portrayed financial statement data, the results confirmed the hypothesis that graphs which violate high-integrity graphics criteria can misled even experienced analysts and viewers of business graphics.

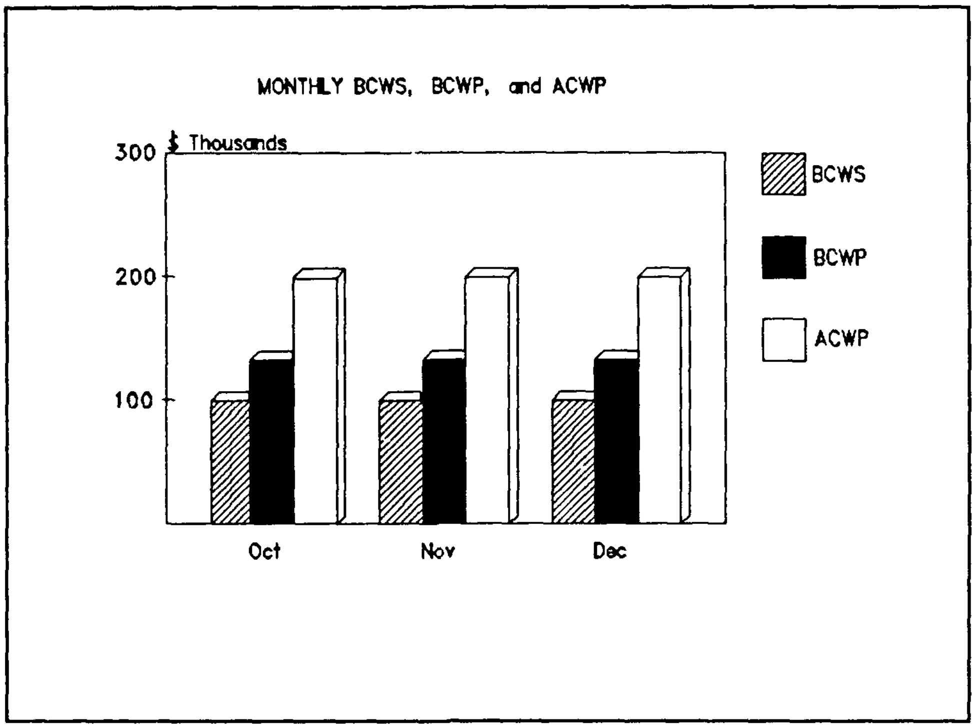
TABLE I

RESULTS OF EXPERIMENT

Graph (Figure)	Significance (P-value)
1	.6133
2	.0000
3	.0000
4	.0712
5	.0004
6	.0098

CONCLUSION AND IMPLICATIONS

Graphs are a very quick and easy way of portraying tabular data. Data from Cost Performance Reports are easily graphed using spreadsheet software and desktop computers. The ease with which this may be done invites the temptation to make the data look better than they should. Accounting researchers, for example, have found that financial statements with adverse financial trends are sometimes accompanied with misleading graphs that mitigate the adverse trend with a more comforting picture [5]. External auditors are beginning to question the propriety of such graphs [8]. Even when there is no deliberate attempt to misrepresent the data, powerful graphics software may enable the user to unwittingly distort the message.



Monthly ACWP is decreasing.

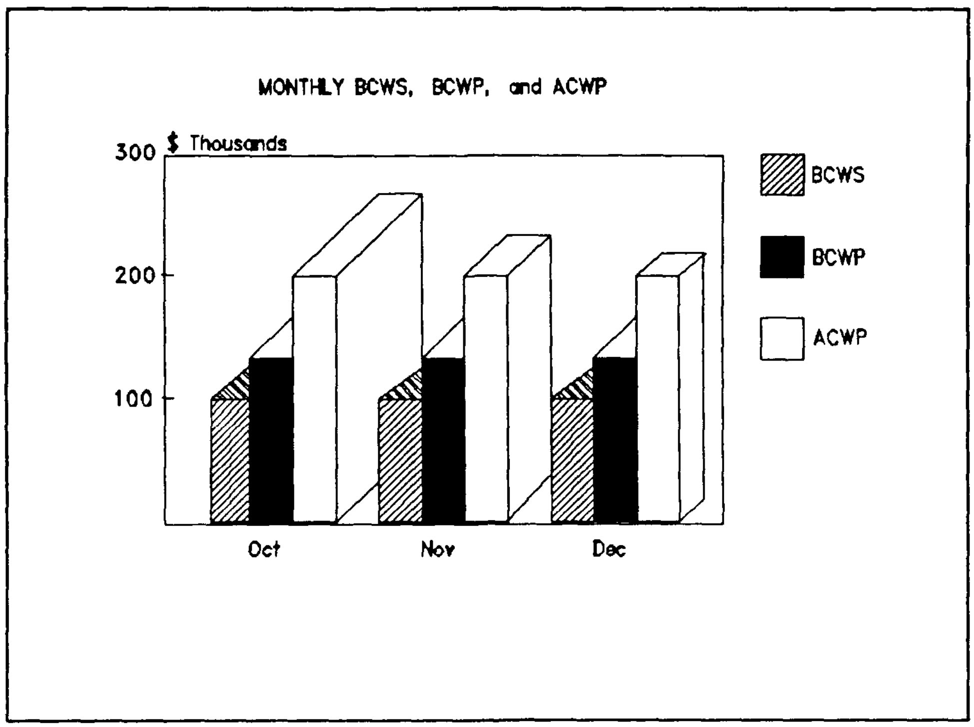
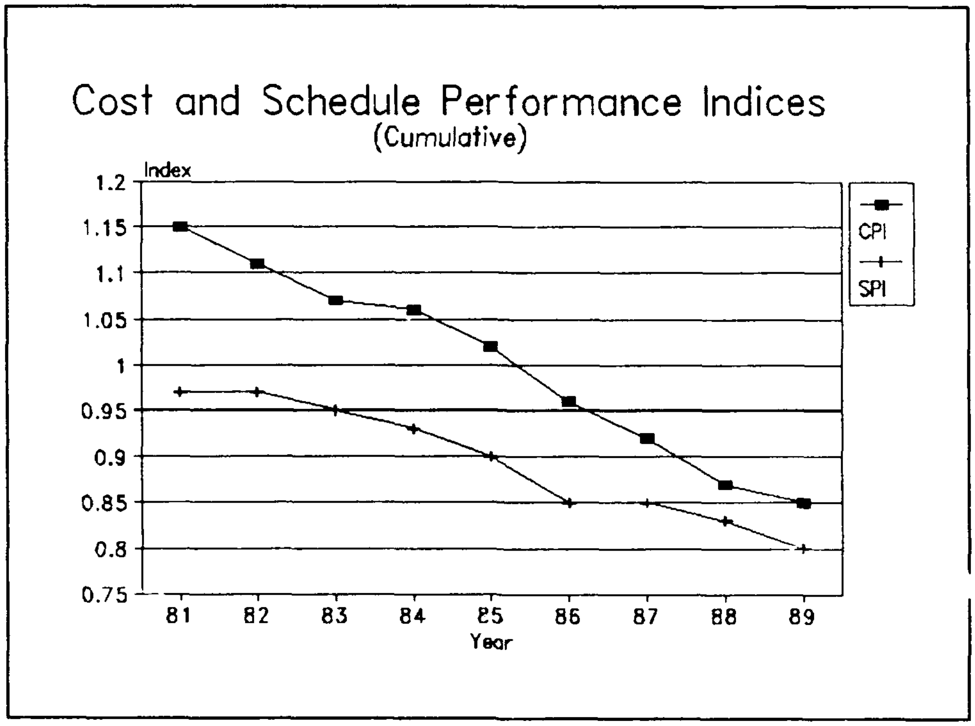


Figure 3 Three dimensional bar chart



The CPI and SPI in 1989 are better than in 1981.

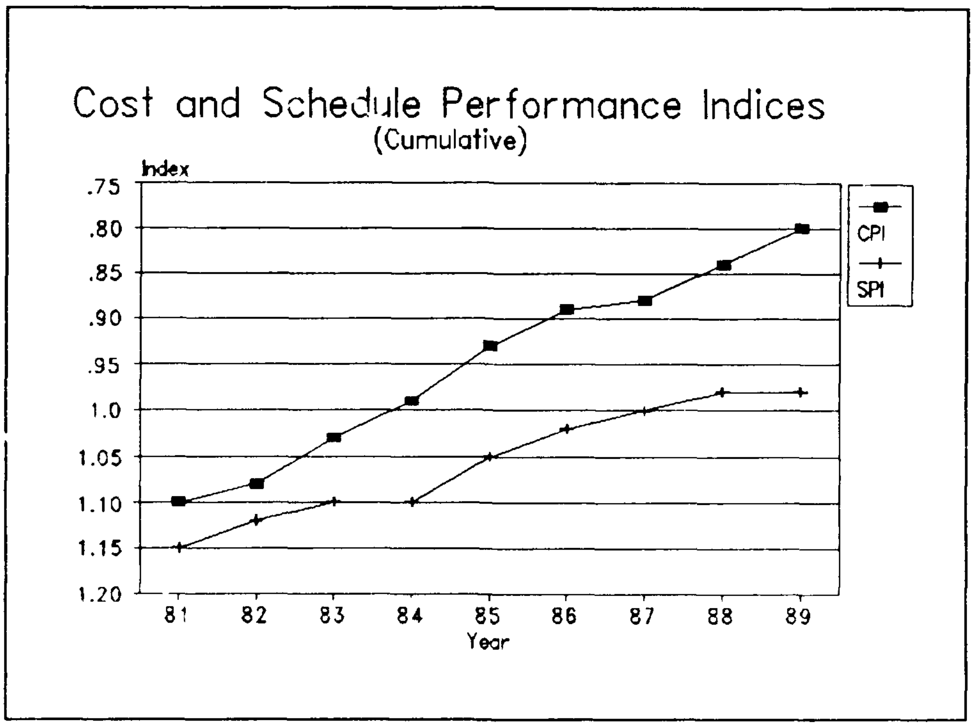
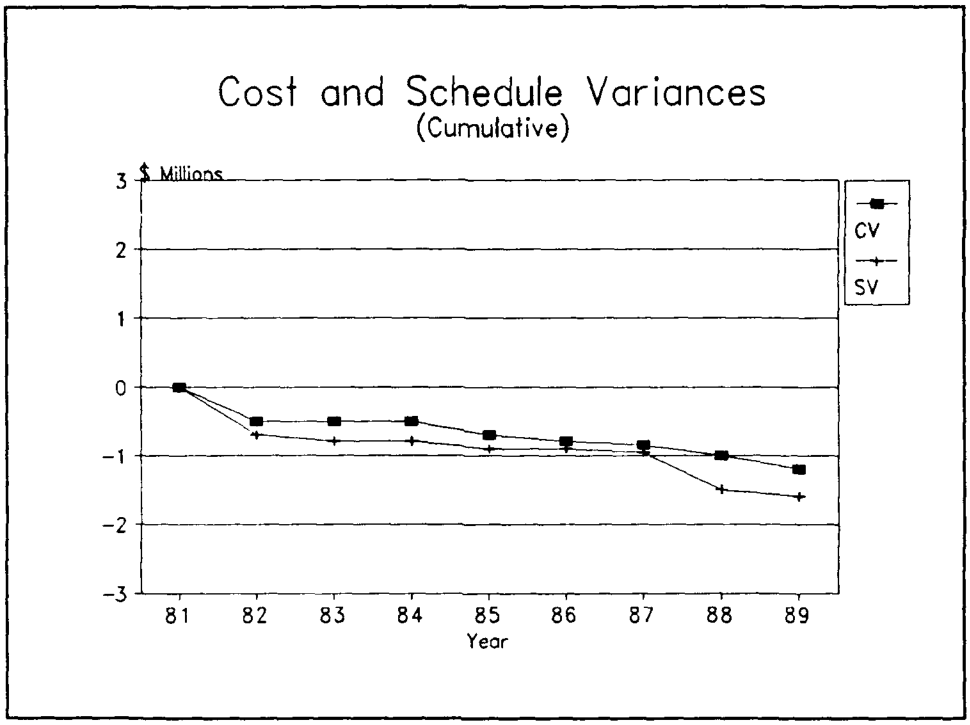


Figure 4 Line chart



The variances reached their worst levels in 1989.

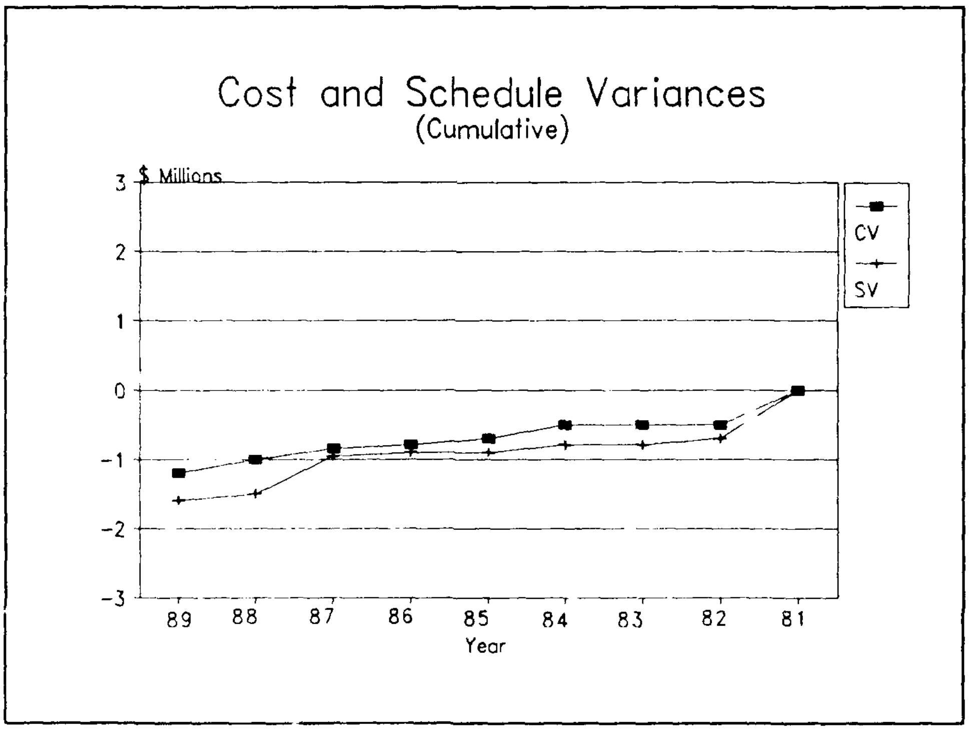
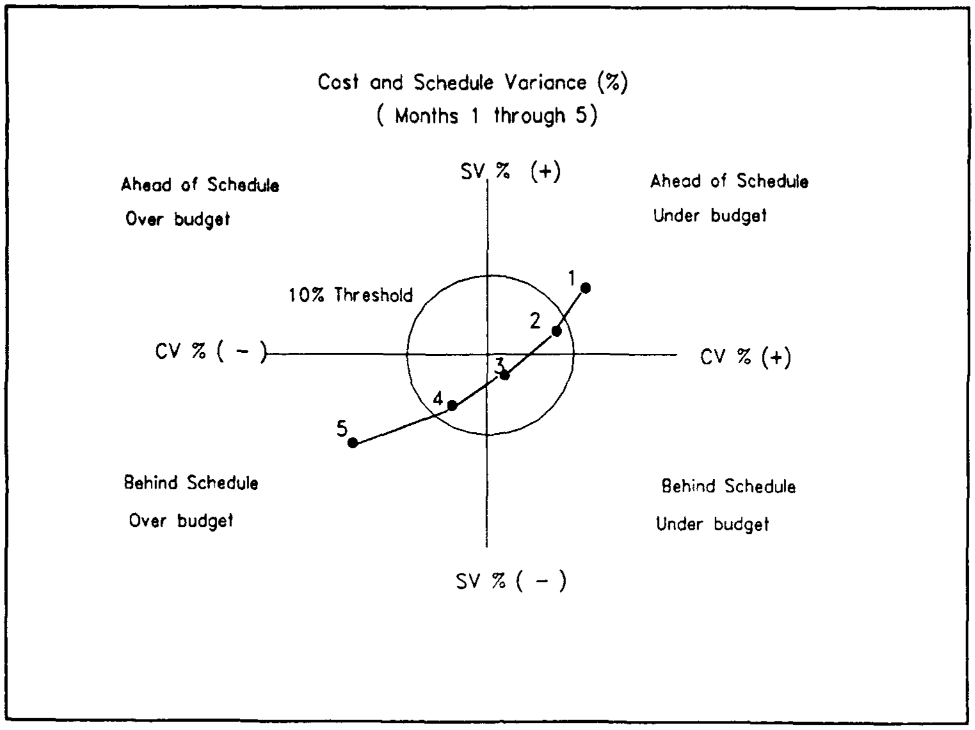


Figure 5 Time series chart



As of month 5, the contractor is behind schedule and over budget.

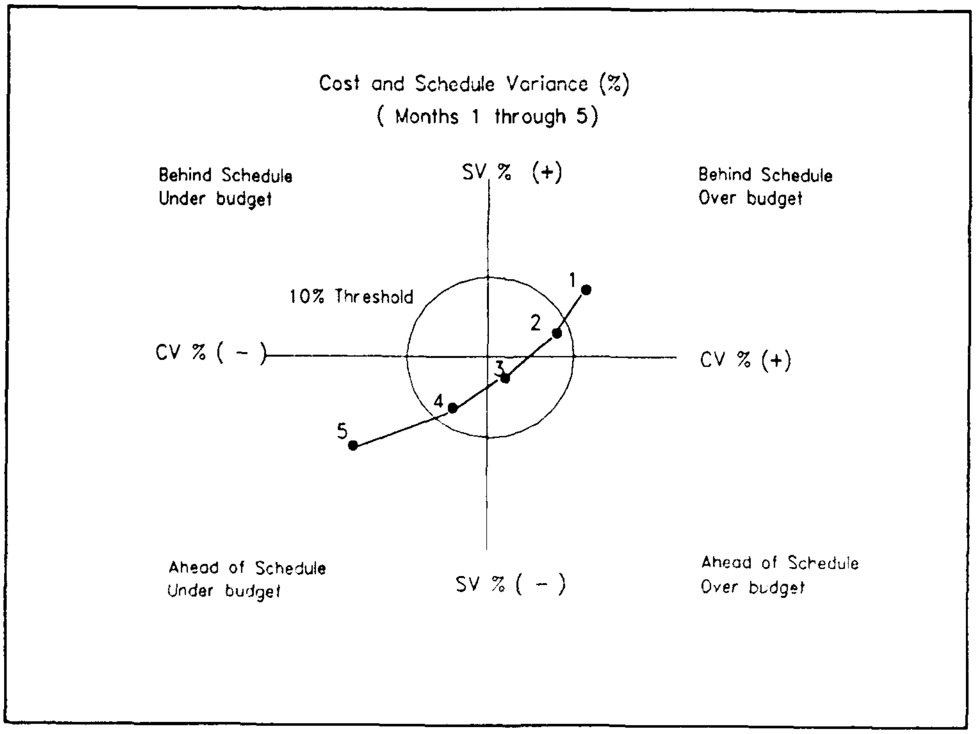


Figure 6 Bulls-eye chart

Presently, there are no effective internal controls against misleading graphics. Software user manuals occasionally warn against certain manipulations, but the software itself rarely prevents the user from abusing its powerful formatting capabilities. Before personal computers and business graphics software, most large organizations had graphics specialists that provided the graphs to managers and other decision makers of the organization. Now it's hard to find a desk without a personal computer, and almost any one can create an impressive graph by pressing a few keys. Few organizations have formalized procedures that standardize graphical presentations or prohibit unusual changes to a graph's format [6]. Perhaps it's time to establish such controls.

Becoming aware of criteria for high-integrity graphics may be an effective control against misleading graphics. Preliminary, ongoing research at AFIT indicates that students who are aware of these criteria are much less likely to be misled.

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ISN'T IT TIME TO STEP BACK FOR A MOMENT?

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ABSTRACT

The theme of this symposium is imagination, innovation, and implementation for acquisition in the future. This paper builds upon that theme. It steps back for a moment and reviews where we are in the field of weapon system warranty analysis, what we have learned during the past five years, and how we can use that knowledge to help achieve our program goals. Using warranty as an integrated part of the weapon acquisition strategy will help leverage the few dollars we may have in the future to provide the maximum possible return.

INTRODUCTION

While warranties have been used in DoD for many years, in 1985 warranties came to the acquisition of weapon systems in a formal way. The 1984 and 1985 Congress was frustrated over the perceived performance of weapons procured by the Department of Defense. This frustration found its way into law, often referred to as the Weapon System Warranty Act, and culminating in section 2403 of Title 10 of the United States Code. Title 10 contains the following main points:

1) The head of an agency may not enter into contracts for the production of weapons systems [subject to specified dollar thresholds and conditions] unless each prime contractor guarantees that:
   - the item provided under the contract will conform to the design and manufacturing requirements specifically delineated in the production contract...,
   - the item provided under the contract, at the time it is delivered to the United States, will be free from all defects in materials and workmanship...,
   - the item provided under the contract will conform to the essential performance requirements of the item as specifically delineated in the production contract...

2) If the item provided fails to meet the guarantees, the contractor will, at the election of the Secretary of Defense,
   - promptly take action as may be necessary to correct the failure at no additional cost to the United States, or
   - pay costs reasonably incurred by the United States in taking such corrective action

3) The Secretary may waive any or part of the above if the Secretary determines that:
   - the waiver is necessary in the interest of national defense
   - that a guarantee under these terms would not be cost-effective.

The requirement is not without theoretical foundation. Authors have indicated that warranties <u>can</u> have a beneficial effect on weapon acquisition.[1] Others have indicated that warranties <u>do</u> have a beneficial effect on weapon acquisition, or that warranty objectives have been achieved.[2-5]

Since 1985, the DoD program managers and contractors have dealt with this legislation. Policy guidance has been written, guides have been published, and training has been provided.

HOW WELL HAVE WE DONE?

What benchmarks exist to measure how well we, the acquisition community (both government and contractor) have done? How have we evaluated ourselves or been evaluated by others? Obviously, benchmarks do exist. Several audits have been conducted and studies published. Two audits dealt with the issue from a broad perspective and are available as a standard of measurement: General Accounting Office reports dated July 1987[6] and September 1989.[7]

The 1987 report included reviews of 97 weapon system contracts of the various services. It said we did well in several areas. Three areas the reviewers believed needed additional emphasis were:

1) The services obtained many warranties without performing appropriate cost-effectiveness analyses

2) Most warranties did not clearly identify the performance requirements that would be assessed

3) Many warranties did not explicitly state whether the contractor was responsible for redesign if performance requirements were not met.

The 1989 report included reviews of 48 contracts of the services. Again, we did well in some areas. But, three points, which the reviewers believed needed additional emphasis, were:

1) Effective administration systems had not been fully established.

2) Procurement activities cost effectiveness analyses were inadequate.

3) Procurement activities were not performing post-warranty evaluations.

Uniformed acquisition professionals also evaluated the activities of specific services. Their conclusions included[8]:

1) Better education is required on military warranties.

2) The PPAC [Product Performance Agreement Center--established by the Air Force to assist program

managers in warranty development and application-discontinued during 1990] should be elevated into a more active role, assisting program offices in their integration of warranties into major weapon acquisition programs.

3) Ensure a common warranty data system is developed which is compatible with standard data systems.

4) DoD needs to clarify and disseminate the options available for using performance warranties to achieve specific weapon system availability goals.

5) A need exists for improved evaluation criteria and procedures for cost benefit studies. The PPAC computerized program [decision support system] and the DSMC warranty handbook should be made official policy guidance.

6) Further guidance is required on waivers, exclusions, and other types of tailoring of warranties.

7) Further guidance is needed on the timing of warranties to ensure the appropriate incentives are available during the different acquisition phases.

8) Policy guidance is needed concerning the amount of risk sharing required between contractors and the government.

Of the suggestions made above, the policy guidance issues are substantially resolved by the handbooks available. The administrative issues, which may seem to drive requirements for new data systems, can be resolved by a more focused definition [a detailed procedure is described in the reference] of warranty essential performance requirements.[9] Periodic evaluation of the effectiveness of warranty continues.

In summary, while some real progress has been made in the areas of providing warranty guidance, training, and decision support systems, much remains to be done in order to make warranty analysis an integrated part of the early system engineering process on a program.

WHERE MIGHT WE BE HEADED?

The thrust of the judgements about how well we have done really deals with two main points:

1) Definition of the problem, and

2) Obtaining a cost effective solution.

With these thoughts in mind let's take a moment to review possible paths which one might follow to satisfy the warranty requirements. Later we'll look at where we should be headed.

One path is to acknowledge, in the final days before the request for proposals are mailed, that one must procure a contractual provision "called" a warranty, because the law says you ought to have one, and that an objective might be to either pay nothing "extra" for that warranty or to pay an "average" price for coverage. Perhaps that path is entered late in the acquisition process. Perhaps that path contains a dialogue with the potential producers that, over time includes comments like these:

"I'm going to need a warranty on this item. Please include it in your proposal."

"Thanks, your proposal doesn't look too bad. I notice that the price of this warranty is 3 percent of the unit price. What exactly does that cover?"

"It may seem a little high, but it's really not. You haven't been very specific about the risk I'm going to have to assume."

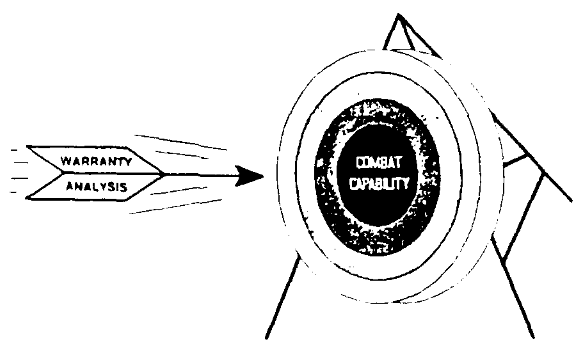
"Fine----two to three percent seems to be about what other programs pay."

The problem with this approach is self-evident. It is not focused on the system or item at hand. It revolves around gross averages accumulated, sporadically, from some other programs. In attempting to solve the immediate problem, we really create another one. It tempts us to consume program dollars unnecessarily as a reflex reaction to some obscure warranty law requirement, rather than integrating warranty into the overall program approach.

Warranty is not an issue which ought to stand or fall on its own. It and the analytical process associated with it is a tool. It ought to be part of an integrated program strategy which begins early in the program and is iterated as the program designers discover more and more about the program's ability to achieve the program objectives.[10]

Another, more productive path might be to apply straightforward analysis to the warranty question. An analytical approach may have revealed, after a review of the requirements, and modeling of possible outcomes based on available data, that even a very small percentage of unit price was too much to pay for warranty, or that a warranty for "no price," but administrative costs, put unnecessary burdens on the user. Perhaps the parameter most important to this item's capability was extremely low risk, and warranty assurance projected was not necessary at all.

Hopefully few program managers find themselves in the first dialogue. Ideally they are on a path which views warranty as another one of the many arrows in their quiver, put there to help achieve an improved capability.



If we don't take the second path, we create an administrative morass for the people who need the capability and a potentially unnecessary financial burden for ourselves.

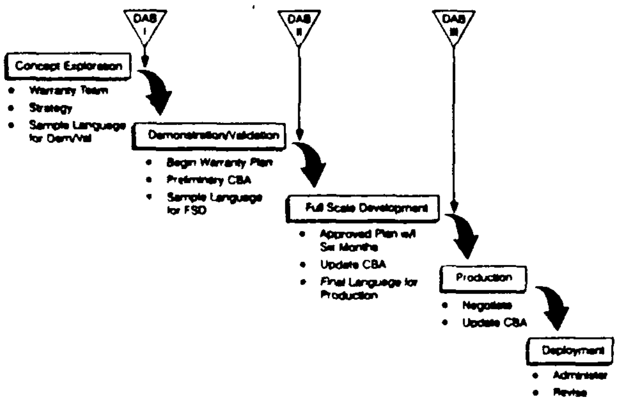
WHERE SHOULD WE BE HEADED?

"There are times when the first duty of intelligent people is the restatement of the obvious"

George Orwell

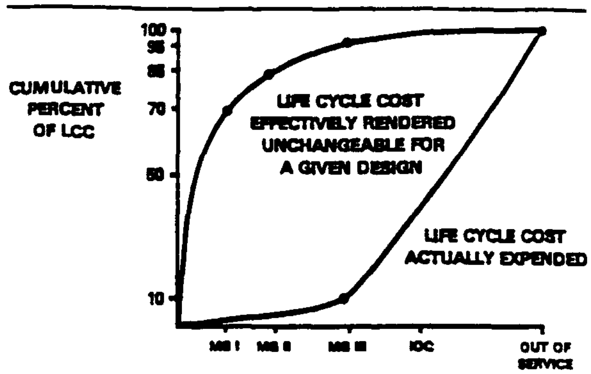
Of primary importance is to obtain improved combat capability with limited resources. Our acquisition process believes that the way to achieve that end is to define the problem early and through a series of iterative decisions, obtain a cost-effective solution. Warranty and the other arrows in the program manager's quiver need to be part of that process [illustrated below] from the beginning. Why? They need to be headed toward the same target. A program with an integrated strategy will help assure that.

WARRANTIES IN THE LIFE CYCLE



Peter Senge of the Massachusetts Institute of Technology described an organization as a collection of arrows. If these arrows are generally pointed in one direction, their effect is additive and the organization moves in that direction. If, as is true in most organizations, arrows are pointed in random fashion, the output and direction of the organization is not a result of the cumulative effect of those arrows. Worse, efforts to improve the situation may be counterproductive if the arrows are not properly aligned. Time and effort spent on increasing the length of the arrows may have a negative effect on the organization's output. Alignment must be the goal of the organization.[11]

Why must we begin early? Because the decisions made early (including decisions to defer, ignore, etc.) are the ones that have the most program impact in terms of combat capability and life cycle cost.[12] This is dramatically illustrated below.



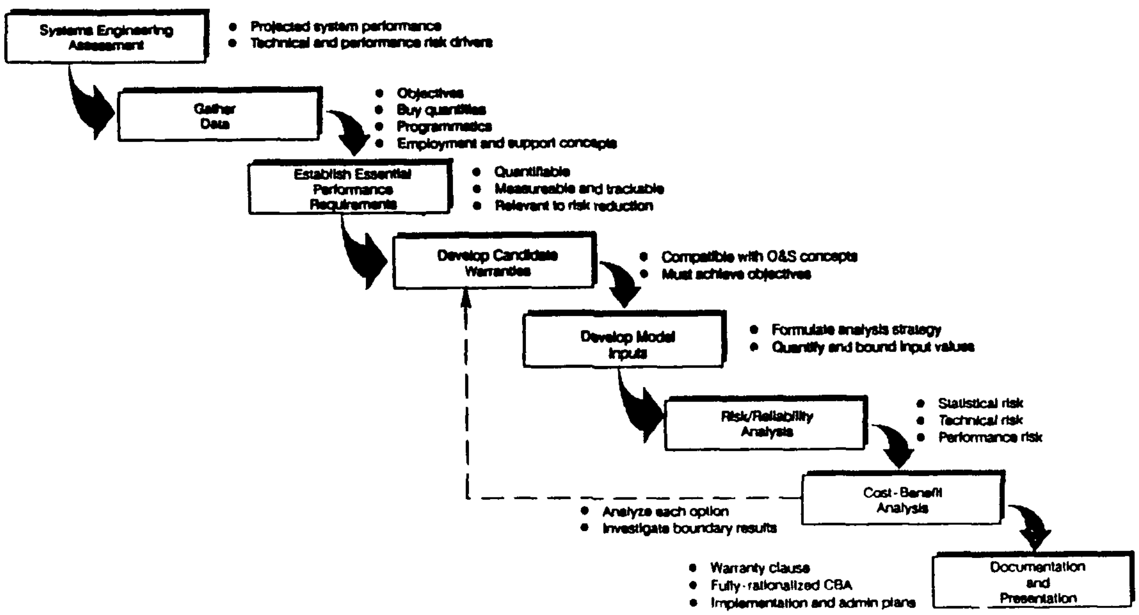
Some believe that warranty falls into the category of "ilities." When it does, it is because of the way it is applied in that particular organization. One author stated, "Ask a program manager, system engineer, or design engineer and he'll tell you that the 'ilities' are not part of the mainstream. They are 'bells and whistles' to be added when convenient." Supporting this perception are the cost burden of these activities on the program, the questionable value received, and the misperceptions that they contribute nothing to performance.[13] How does one fix this problem? By becoming part of the design process. By getting involved rather than standing on the outside and looking in. By becoming a part of the solution rather than another problem. This means moving the warranty consideration back to the program manager or the chief systems engineer, rather than in the financial or logistics community. The process illustrated below is one familiar to the systems engineer. It is a process that begins early and iterates throughout the acquisition life cycle.

and procured with no consideration as to how the provisions were going to be administered and with little regard to the impact on the user.[15] We need to <u>craft</u> the warranty with the trooper/sailor/airman in mind. The process above and talented analysts will help do that and not burden the troops.

SUMMARY

We have adjusted to the fact that the Weapons System Warranty Act is here to stay. The

WARRANTY ANALYSIS METHODOLOGY



By considering warranty in this way, we help leverage our resources to provide the soldier what is wanted. The user is interested in operational field performance, not tests or analysis results, not relevant or irrelevant failures. All failures are relevant to the operational commander.[14] Examples abound of warranties developed

mechanisms, regulations, and direction are in place. We need to focus its use more effectively, by making it a systematic consideration as part of the design process-rather than an additional administrative burden to be added at the end of the process. Some programs are actively, in the systems engineering process, considering the potential influence of warranty. Provisions which represent considerable thought on the part of some program offices are appearing in draft RFPs disseminated for industry comment in advance of FSD. This sends a clear signal that the government expects warranty to impact the design process. Others are not sending such a clear signal.

Consider warranty early. When it makes sense to use it to help achieve program goals, use it. Where not possible, let's recognize it and use our imagination to implement other reasonable and cost effective alternatives.

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ACQUISITION SYSTEMS PROTECTION, KEEPING THE TECHNOLOGICAL EDGE

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ABSTRACT

In recent years, the United States has relied upon the technical superiority of its weapon systems to assure the superiority of its military forces. Our technological lead has permitted us to satisfy national security objectives with smaller forces and high technology systems having a greater capability than larger forces with less capable systems. While our high technology approach has proven successful in many ways, the period of time for which a specific system has retained its technical superiority has often been shorter than expected. Potential adversaries have been able to develop countermeasures and field more capable systems earlier than we had anticipated. Among the principal reasons they have been able to do this is their ability to gain access to sensitive technical information about developing U.S. systems. All too often access to U.S. technical data is gained by foreign intelligence collection methods being targeted at specific U.S. defense programs, while other sensitive technical information has found its way into the open literature in the public domain.

Recent activities within the DoD have shown the need to increase our efforts to protect sensitive technical information. The DoD Acquisition Systems Protection Program is being established to deal with this need. The DoD objective is to increase the time period when a U.S. system has technical dominance over a threat counter or offsetting system. This paper summarizes the recent activities in the Acquisition Systems Protection Program and highlights new requirements in response to this important initiative.

INTRODUCTION

The protection of United States sensitive information and installations has always been a primary objective of the Department of Defense. There are few topics that are viewed more seriously. "Security is everyone's business." The protection of classified information and the proper management of people with knowledge of this information has been a subject for major emphasis. Approximately $11 billion dollars are spent annually on all forms of security for the protection of defense personnel, facilities, information and systems. This large expenditure reflects the seriousness of the matter, yet there can always be improvements as we adjust to the current challenges.

Improvements have been identified for the protection of acquisition systems by increasing the security surrounding weapons system requirements, design particulars, and test data generated during weapon system development. In this context, acquisition systems are defined to include those weapon systems anywhere in the acquisition process as well as the technologies being developed that could lead to weapon or weapon support (i.e., command and control) systems.

The improvements will embody two cardinal principles of security:

- Assets should be available when needed. Security is intended to ensure that valuable assets are securely protected, and therefore, available when needed.

- Assets should be usable when needed. Similarly, security should ensure that these available assets are usable when they are needed. "Usable" means not damaged or impaired in some way, but it also means that the systems can be used without unexpected interference from a threat system or countermeasure.

Accordingly, security means preventing potential adversaries from gaining access to information that would limit our ability to employ our systems or information that would aid in the development of countermeasures.

BACKGROUND

Our current initiatives in acquisition systems protection are the result of a confluence of events. The two major paths of interest, one in the Office of the Secretary of Defense and one in the Congress, have resulted in an increased emphasis and a new initiative to deal with this topic. Within the Office of the Secretary of Defense, there has been increasing concern about the protection of sensitive information. This is particularly true in the research, development, test and evaluation (RDT&E) area, where technical data for new systems is gathered and shared within the DoD laboratories, development centers, test ranges and the defense industrial base.

One activity that defined the situation and focused our recent initiative was a review conducted under the leadership of the Office of the Under Secretary of Defense (Acquisition). The Protection of the U.S. Technical Lead (PTL) Review Group examined the threat and security issues in system acquisition. The report of this review group (Ref. 1) included a number of findings and recommendations. A summary of principal findings is shown in Figure 1 and key recommendations are listed in Figure 2.

A second series of events took place during the review and approval of the FY91 DoD budget by the Congress. Reports by the House Armed Services Committee, the House Appropriations Committee, and the Senate Select Committee on Intelligence expressed concern about the protection of information on technologies of systems in development. Specifically, the congressional reports recommended:

1) the establishment of an oversight office within the Office of the Secretary of Defense;

2) the identification of acquisition systems protection funding; and

3) the development of an overall strategy to correct acquisition-related security deficiencies.

Principal findings of the PTL report include:

- System classification guides are not comprehensive documents
- There is no institutionalized process to determine what measures a program should employ to protect critical information
- Security is given a low priority for the resources and manpower available to program managers
- Security at T&E sites has a low priority compared to other infrastructure improvements
- There is no information security training for program managers and acquisition personnel

(Ref. 1)

Figure 1 - Principal Findings of Protecting U.S. Technical Lead (PTL) Report

These recommendations will foster organizational or procedural changes, as well as the investment of prudent resources to provide the facilities and equipment needed to safeguard the critical technical information.

ACTIVITIES TO DATE

In August 1990, the three Military Departments signed a memorandum of agreement (Ref. 2) establishing the Joint-Service Acquisition Systems Protection Program (JASPP). The JASPP is composed of representatives of the Service

Key recommendations of the PTL report include:

- A system protection plan should be required for all major acquisitions
- A security survey should be performed for every major system
- Funding requirements for security measures should be tracked
- Guidance should be developed for acquisition security training
- New USD(A) element should be formed to develop a DoD-wide Acquisition Protection Master Plan and review system protection plans

(Ref. 1)

Figure 2 - Key Recommendations of Protecting U.S. Technical Lead (PTL) Report

secretariats and functional experts in acquisition, test, intelligence, and various security disciplines from the Services. Participation of other DoD and non-DoD organizations have been solicited. The major objective of the JASPP is to seek and recommend comprehensive, integrated, executable, and affordable protection methodologies for critical and sensitive weapon systems design information and test data generated throughout the acquisition process. The actions of the JASPP include those listed in Figure 3.

On January 10, 1991, the Acting Under Secretary of Defense (Acquisition), Mr. Donald J. Yockey sent separate memoranda (Ref. 3) to the Director of Defense Research and Engineering (DDR&E), the Secretaries of the Military Departments, the Chairman of the Joint Chiefs of Staff, the Director of the Defense Intelligence Agency, and the Chairman of the Joint Requirements Oversight Council. These memoranda highlight information presented in the report from the Protecting the Technical Lead (PTL) review group (Ref. 1). The memoranda also outline actions being taken by USD(A) and actions to be taken by the addressees. Figure 4 lists some of the actions directed within USD(A) memoranda.

The Acquisition Systems Protection Office has been established within the office of the Director of Defense Research and Engineering (DDR&E), specifically reporting to the Deputy Director for Plans and Resources (DDR&E(P&R)). The ASPO is assigned a number of responsibilities by the USD(A) memoranda. Among the most important are the requirement for a review of the security classification guidance and program protective measures for each major acquisition program, and the requirement for the ASPO to provide an assessment of the program protection measures for each major acquisition program to the appropriate Defense Acquisition Board (DAB) committee prior to each milestone review.

The ASPO is devoting attention to the policies and procedures that apply to those areas of RDT&E that cut across program

The actions of the JASPP include:

- **Review of procedures relating to selected security, intelligence, logistics, and operational functions and procedures as they support weapon system acquisition and recommend improvements**
- **Sharing of lessons learned and results of security surveys**
- **Standardization of capabilities which support protection of weapon systems design and test data**
- **Joint investments in studies, training, and related efforts**

(Ref. 2)

Figure 3 - Actions of the Joint-Service Acquisition Systems Protection Program (JASPP)

Summary of Actions in USD(A) Memoranda and Their Status:

- **Establish an Acquisition Systems Protection Office (ASPO) within the DDR&E staff. - Office reports to DDDR&E(P&R).**
- **Establish a "horizontal protection program." - Underway in ASPO.**
- **Develop an Acquisition Security Master Plan for DoD. - Being prepared by ASPO.**

(Ref. 3)

Figure 4 - Actions in the USD(A) Memoranda

lines and to those technologies (subsystems and major components) in the technology base that have not yet been assigned to a program manager. These areas are most difficult to address since multiple organizations or managers are involved. They should be of a high priority, however, since early technology efforts may be the most fruitful in providing significant technical breakthroughs. Emphasis will be on the early protection of innovative approaches and unique technologies.

PLANNED ACTIVITIES

The protective activities to be pursued under the leadership of the ASPO can be categorized into two areas, DoD infrastructure and acquisition programs. By acquisition programs, we mean the composite of the organization, personnel, planning, schedule and all other items that are needed to successfully complete the development of a weapon system and to place it in the hands of its users.

DoD Infrastructure: The infrastructure activities will be focused at facilities and activities that are used by many or all acquisition programs. This includes security at the test and evaluation facilities as well as at the DoD laboratories, development centers, and the development contractors. Infrastructure activities will include revised training programs, revisions to DoD directives that all acquisition programs use, and improvements to the communications methods within DoD and with our defense contractors. The infrastructure activities must result in an improved environment that is supportive of the program manager's activities. The protective measures in the infrastructure must not degrade an otherwise well-protected acquisition program.

Acquisition Programs: The acquisition program activities are actions that must be addressed by each acquisition program manager. In the early stages of an acquisition program, the program manager must determine:

- what is critical about the program,
- how this information is best protected,
- how long the information should be protected, and
- how to assess if the critical information has been lost.

A Program Protection Plan is envisioned to address integrated security measures and counterintelligence aspects needed to ensure the security of critical technologies, unique program characteristics and system design features that would be of interest to an adversary (hostile threat collection activities). Decisions on how to protect the critical data if the systems are to be sold to our allies, must also be addressed early in the protection planning process in order to structure protection for the critical technology.

The ASPO is to start five activities during FY91-92 in order to achieve the acquisition systems protection initiative's goals. First, in the near-term, the ASPO is working to form a base line of when each type of major RDT&E activity (i.e., laboratories, test ranges and other facilities) has all the protection warranted. This will become a standard by which we measure RDT&E facility protection. Surveys will be conducted to determine how each major facility compares to the standard, what must be done to fix the major problems, and what it is going to cost.

A second activity will be to construct an Acquisition Systems Protection Master Plan to identify the funding to fix the security problems of the RDT&E facilities over the next few years. The protection master plan will address topics such things as the education of acquisition personnel on the need for and the principals of acquisition protection.

A third activity will be to incorporate system protection into major acquisition education and training courses.

In a fourth activity, to support individual system protection planning, the ASPO is working with the Services and Agencies to identify personnel with specialized protection expertise to support the major weapon system programs. The ASPO will work to ensure that the program managers and their staffs get the support that they need to properly protect their program.

The final activity is one that must be approached with creativity. This is the continuous evaluation of the entire acquisition system protection effort. The ASPO is establishing a "horizontal protection" program that uses a list of critical technologies as an initial basis for an assessment of where we stand on protecting our critical systems. As individual program efforts are implemented, Essential Elements of Friendly Information (EEFI) will be compiled and added to critical technologies.

All of these efforts, infrastructure improvement, program protection and horizontal protection, will be folded into the DoD Acquisition Systems Protection Master Plan. The Master Plan will serve as a five-year management plan to give the structure and discipline needed to pursue successfully, these varied protection activities.

HELPING THE PROGRAM MANAGER PROTECT THE SYSTEM

The subject of acquisition system protection must be given renewed emphasis. Certainly, the program manager's responsibilities are broad, complex and demanding. System protection must receive the needed consideration in the early stages of the systems acquisition process when cost, schedule, performance, and supportability are initially considered. Realistic protection measures have to be determined before the Milestone I review to ensure that security parameters are fixed within the overall system acquisition strategy. This early protection planning will ensure that security is an integral part of the strategy that at a minimum should strive to maximize or at least extend the period of fielded technological superiority. A time phased, well-planned set of appropriate protective measures must be applied as the program proceeds through the acquisition process. Specific measures may be added or deleted from the plan as appropriate. Cost-effective security must be a planned, integral part of the acquisition program. It should not be dealt with as an afterthought, without the needed resources.

To help in structuring the needed acquisition system protection effort within the major *acquisition systems programs*, the soon to be published revisions to the 5000 series directives will require early protection planning for each major system (Ref. 4). The Program Protection Plan will be required to address the use of the integrated security disciplines, such as counterintelligence, communication security, operations security and physical security, to devise a coherent protection program. The Program Protection Plan will be developed by Milestone I and updated for each subsequent milestone. Other revisions may be necessary to address changing conditions as the system is developed. The plan will encompass program related activities at laboratories, development centers, test ranges, contractor facilities, and deployment locations as required to provide protective measures for all aspects of the acquisition program.

To scope the required security effort, the program protection planner must have an understanding of the protection threats and the program vulnerabilities. There should be a direct correlation between the threat the system is projected to counter or operate in, as defined in the system threat assessment, and the foreign intelligence collection threat against the system acquisition program. The plan must define the resources (personnel, equipment, and funding) that are required in each acquisition phase to provide the level of protection that is necessary for the protected elements of the system. Unfunded protection requirements will require adjustment to the Protection Plan to reflect an effort that matches the available resources.

CONCLUSION

To realize the real benefits of our investments in new technology requires a renewed effort to ensure that the security of critical weapon system design information or test data is maintained. The entire DoD acquisition community must respond to this challenge and not expect the individual program managers to shoulder the protection effort alone. Funding for fixes for infrastructure protection problems and individual program protection planning and funding must support current actions. From a DoD viewpoint, the Acquisition Systems Protection Program must be a "Service oriented" program that helps the program manager get the support that is needed for an effective protection program. From a national viewpoint, the government (DoD) and the industrial base must be held accountable to the national populace for technical security protection. The acquisition of Defense weaponry is populace for technical security protection. The acquisition of Defense weaponry is fundamental to the purpose of government in order to defend national interests. To this end, the protection of our defense technology is paramount.

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USING EXISTING QUALITY INFORMATION IN ACQUISITION DECISION-MAKING

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ABSTRACT

As we seek to improve our systems, greater importance is placed on the quality of the components, materials and spares used to operate and maintain them. Feedback of information among quality, contracting, production and program management organizations is a key element of successful quality acquisition planning.

Most organizations collect information which directly relates to the quality of their purchases. Because contracting, quality, program management and commercial production report to different masters, impediments develop to a free flow of information. Outside of the obvious reluctance to rely on information collected outside of one's organization, there are data base incompatibly issues. Because changing data collection methods can be expensive, organizations often become discouraged from developing quality based contracting or purchasing systems.

Accomplishing a free flow of information can be facilitated through the reapplication of much of the information already being collected. Depending on the size and complexity of the activity, its product and its organizational structure, different approaches to the problem are appropriate.

The following seven characteristics are essential to successful implementation of quality contracting systems.

(1) clear identification of key quality variables
(2) identification of existing quality information regardless of its source
(3) integration of existing information systems, and development of a common comparison basis
(4) introduction of suppliers to the system
(5) trial data collection period
(6) full implementation, bid factors or other source selection criteria used to evaluate offers.
(7) process reevaluation to make it more useful and responsive.

The key to successful implementation is feedback. Quality information becomes more accurate as it is used. Successful implementation of such systems will be discussed.

INTRODUCTION

"Quality contributes to the bottom line" succinctly summarizes the motivation behind the emphasis placed on quality in all aspects of American manufacturing. It is difficult to identify many firms which do not have some on-going program to improve the quality of their products. The emphasis has been placed on the manufacturing process, focusing on "doing things right the first time" and "process control." Unfortunately in the area of military/industrial purchasing, previously there were few concrete tools available to contracting management which will permit application of objective and measurable quality standards in the contracting process.

Throughout DoD and industry there is a desire to show commitment and results from implementation of quality improvement efforts from top management. By developing a contracting system which objectively weights quality, the problem becomes one of balancing quick results to demonstrate commitment to quality improvement against an integrated and systematic approach which will provide better long term results.

THE EXPANDING ROLE OF QUALITY

The importance being placed on quality output by DoD is promoting a greater emphasis on all aspects of the production process. Within the commercial purchasing environment, the closer supplier relationships advocated under Total Quality Management and necessary in Just-in-Time arrangements are part of industry's response to improving the productive inputs. Another innovation is the role which quality data can play in the purchase decision making process. However, DoD activities are encountering more difficult integration challenges as they try to define, measure and apply quality information to their contract decision making.

DEFINING QUALITY

Quality is often referred to as something tangible, or "obvious to the casual observer." Practically, quality can be viewed on both the objective and subjective levels. Like love, you see concrete indicators of its presence or absence, but it remains a term which defies precise definition.

In surveys taken by the author of commercial and government purchasing officials, quality was most frequently defined as "fairly priced item which performs as it is supposed to," with "conformance to specifications" a distant second.[1] While both are familiar applications of Crosby's and Juran's definitions, neither makes the application of quality data to the purchase environment easy. Both open new aspects of ambiguity. Who determines whether an item is "fairly priced" or that it "performs as it is supposed to?" Or do you select an item which barely "conforms to specification" over one which exceeds all the specifications?

DEFINING QUALITY BY KEY DIMENSIONS

David Garvin provides a useful approach to defining quality.[2] He explores the different results which may be obtained depending on whether one views quality from a transcendent, product-based, user-based, manufacturing-based or value-based approach. To briefly illustrate, a beautifully hand crafted violin may fail a manufacturing-based definition because it does not precisely conform to established specifications. Conversely a precision manufactured violin may not satisfy the transcendent measures of tone or feel.

To provide a more useful technique for constructive application, Garvin proposes viewing quality in eight dimensions: performance, reliability, conformance, aesthetics, serviceability, features and perceived quality. In contracting, different weights may be placed on these dimensions depending on their application. For example, the pen and pencil we select to send off to school with one of our children is purchased under different criteria than ones we would purchase as a gift. Clearly the technique of looking at quality in dimensions provides a constructive approach to bounding the quality measurement problem.

QUALITY MEASUREMENT

The problem of quality measurement is compounded by the lack of accurate and timely feed back information to the buyer. In major personal purchase decisions we approach the problem from the viewpoint of personal past history, input from friends, supplier information and perhaps even refer to an independent testing or consumer advocacy organization. Since we are both the user and the buyer, there is no loss of pertinent information in translating our requirements into a purchase. The size of the purchase and our own personal experience or instincts bound the level of research we undertake. Satisfaction favorably disposes us to make subsequent purchases, while problems make later purchases unlikely.

Government contracting seeks the same objective, however, the user and the buyer must clearly communicate. Implicit in this communication is the potential for misinterpretation. Additionally in government contracting there is the problem of physical and organizational separation. The ability for the user to walk up and sit on the contracting officer's desk is rarely present.

Both of the definitions of quality from the survey imply a feedback loop of performance information. This loop can be best described in the terms of a simple purchase arrangement involving a user, buyer, supplier and quality assurance.

Each purchase begins with requirements, specifications or performance criteria being provided to the buyer. This buyer negotiates with the supplier the terms and conditions of the purchase. The quality control organization may be involved in certifying the quality systems of major suppliers, conducting receipt testing or other techniques. Applying the definitions of quality most commonly given, the delivered product would satisfy those requirements, specifications or performance criteria at a fair price.

The purchase cycle described is sequential. The reverse flow of quality information is not necessarily sequential. In the survey referred to above only 21 percent of the responding Navy contracting officers believed that quality data was systematically reported back to them.

EVALUATING PRICE

The purchase decision consists of balancing product characteristics and price. The one part of the equation which is absolute is price. Promised characteristics can be compared against requirements, but since their attainment is in the future, at a different location, measured by a different organizational entity, price receives disproportionate weight.

Because in the absence of additional information, the buyer responds to price and an unsubstantiated performance evaluation. Many companies and DoD organizations are working toward providing the buyer with a more real time quality information. Forward looking firms and government activities are working to develop systems which can be used to factor quality data collected from various organizational elements into the decision process.

Because the quality and purchasing functions were historically separated, this eliminated a valuable interchange of information between the functional entities. At its worst it results in dissatisfaction by users that no one is paying attention to their interests as the inferior items continue to be procured.

The availability of computer tracking systems and the potential to link the purchasing and quality data bases is a natural application of information systems to practical problems.

Efforts are underway under the auspices of the Defense Logistics Agency to link the purchasing and quality information in a common data base.

The optimal result is not an expert system which makes the contracting decision but a decision support system which requires the purchasing manager to evaluate information and then apply personal judgement in making the selection.

Such decision support systems are not a threat to the contracting officer but rather a powerful tool to improve the quality and performance of supplies.

Academic studies of vendor performance show that it is the poor performer who benefits from uncertainty in achieving quality because quality is an economic second best variable.[3] If quality cannot be clearly established and quantified, it tends to be subordinated to price.

Excellent suppliers will welcome such systems because they will be rewarded with more business. All suppliers will become more sensitive to the requirement, specification and performance indicators when they realize that cutting corners to reduce price can result in an upward factoring of their price.

IMPEDIMENTS TO IMPLEMENTATION

If such systems are such a good idea why are they not uniformly in use? The most significant of the impediments is the lack of an integrating data base system available to the contracting officer. Unless information available to the contracting official is complete, timely and accurate, it will be subordinated to this individual's personal knowledge of the market and price.

The second is the invisible line between the quality and purchasing departments. Disputes over ownership of data with resulting format and other barriers can keep government activities possessing an impressive array of quality information but lacking the integration necessary to use them effectively in making source selections.

<u>PREREQUISITES FOR SUCCESS</u>

APPLICATION SPECIFIC

Successful implementations are first and foremost tailored to the organization's requirements. If a simple system based solely on an analysis of on-time delivery meets the requirements, it need not incur the data collection and processing costs associated with a fully integrated system. Conversely, sophisticated integrated manufacturing firms should not rely solely on data which is easy to collect ignoring other existing data sources.

PENALTY FITS

In order to accurately assess the factor by which price quotations would be adjusted based on past performance, the firm must clearly look at its cost structure. Representative questions to be answered include:

> How much does a delivery delay of one week cost in work-arounds?
>
> What is the cost of rework caused by a defective part in production?
>
> What is the operational impact of an item being returned from a customer activity?

Penalties assessed should become progressively more severe the further the problem is discovered in the production cycle. The rating given a supplier must also be adjusted to reflect the volume of business.

COMPLETENESS

The data base should systematically collect and display information on suppliers from all sources. This requires the cooperation of all custodians of quality or contracting data bases. An activity should genuinely question the utility of maintaining a quality data base which is not included in this integrated system.

INVOLVING SUPPLIERS

Quality contracting systems must be sold to suppliers as fair, comprehensive and measurable. Providing early information on the key elements of the system and an extensive trial period is crucial to making the est suppliers partners in the process. To be truly effective the suppliers must understand the measures which will be emphasized and how the data will be collected.

DRY RUN

Informing suppliers of their rating during the testing phase is crucial to making the best suppliers partners in the process. A period lasting twelve to eighteen months of collecting data and reporting it back to the supplier will
accomplish three goals.

Validation of data collection system as suppliers highlight discrepancies.

> Interim improvement of supplier performance as it becomes clear to them how they compare to their competitors.

> Determination of the effectiveness of the system as an internal tool to the company.

CONCLUSION

The real challenge to firms and DoD activities looking to make quality a more important part of their source selection process is how to accomplish this within current and anticipate resource constraints. One or more of the following three strategies can be effective.

The first is to shout that quality is important. Develop slogans and create enough doubt in the mind of suppliers that you are serious.

The second is to find a measure and report it back to the supplier. Whether this measure is highly accurate or not it will create even more doubt in the mind of the supplier that you could be serious. The logical extension of this measure is to drop suppliers who perform very badly based on it.

The third is to integrate all available measures into something resembling a composite quality rating system.

In the ne: several years we will see evolving a.i increasingly sophisticated approach to quality sourcing decisions in industry and government. Full implementation may not be practical for all activities because of the expense of development and maintenance. However, if there are one or two dimensions of quality which exert the largest influence on the cost structure or mission of the DoD activity, a system can be structured to objectively and accurately measure performance.

A quality purchasing system is a very important competitive tool in a firm's efforts to improve its quality and bottom line performance, and a tool for government contracting to reduce cost.

ENDNOTES

1. The surveys were taken of a random sample of the National Association of Purchasing Management and Navy contracting officers and program managers in the summer/fall of 1988.

2. Garvin, David A. Managing Quality, The Strategic and Competitive Edge. New York: The Free Press, 1988.

3. Thoman, Lynda. Repeat Purchases Under Quality Uncertainty. A Dissertation, Stanford University, September 1984. and Baumann, Michael Gerard. The Efficiency of Markets in Supplying Quality. A Dissertation, Harvard University, October 1984.

PROMPT PAYMENT

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The time required to process invoices for payment to vendors for low-dollar off-the-shelf items is so lengthy that penalties are incurred for late payment. The purpose of this paper is to suggest feasible methods to reduce the time period required for payment and, accordingly, penalties incurred.

Introduction

The term "acquisition" is an all-encompassing term and usually pertains to those activities ranging from initial planning through fielding. This includes contracting and, by extension, contractual payment. Imagine a scenario where a company manufactures a product for $1 and sells it for $4 to the Government, winning every contract on which it bids. However, soon the company management notifies the Government that it can no longer afford to do business. "But why?" asks the Government official. "You make tremendous profits." "On paper, yes," replies the company official. "However, we don't see the money because you never pay us."

Admittedly, that scenario is a bit exaggerated, but the premise is certainly valid. As any businessman or woman will attest, money is not a free commodity. However. a perception has been perpetuated among the business community that the Federal Government does not subscribe to that axiom by not recognizing the time value of money. The basis for this feeling is the bill-paying practice of the Federal Government in general, and specifically, the Department of Defense.

Statement of Purpose

This paper will deal with the Prompt Payment Act and associated regulations and the way that they relate to purchases of small-dollar "off-the-shelf" items. Quite simply, the process is as follows: the order is placed, the product is delivered, documentation is presented, and payment is expected. Of course, no one wants to pay for something until they are certain it has been received and that it conforms with the terms of the contract. All of this can take time.

Time, however, is something with which most vendors are not heavily endowed. In order for a vendor to be successful in the long run, the pace at which funds are expended should not greatly exceed the pace at which funds are received. No matter the value of its contracts, a vendor cannot remain in business if all of its assets are in the form of receivables, as opposed to operating income. This problem is particularly acute with vendors who fill orders for commercial "off-the-shelf" items since these vendors are usually not heavily capitalized.

Payment System Prior to Prompt Payment Act

In 1978, a study by the General Accounting Office (GAO) determined that 61 percent of the Government's bills were paid within 30 days and 85 percent were paid within 60 days.[1] After taking into account the delays which were attributable to contractors, it was found that 70 percent of the Government's payments were made on time. That particular study found that delays which were attributable to contractors were caused by not promptly providing correct invoices to the proper payment center. Government caused delays were attributed to problems in assembling the paperwork needed to make payment.

Of course, if 70 percent of the Government's bills were paid on time, by extension, that means that 30 percent were paid late.

By 1981 the situation had deteriorated so that in testimony given before the House Government Operations Committee, Subcommittee on Legislation and National Security, one witness remarked, "We will not work for certain Federal agencies...even if it is...a specific type of work that we do and are good at it. We will not compete."[2]

The goal of the Government in dealing with the contractor is "payment by the due date," neither late nor early, unless a discount is offered and the terms are favorable.[3]

The reader should not be deluded into thinking that the Government is uniform in the timing of its payments - late, early, or on time. In a second study, not affiliated with the one previously mentioned, the GAO found that 45 percent of the invoices of the Federal Government and 25 percent of the dollar value were paid early, with the vast majority occurring more than 15 days before the due date.[4] This is a definite problem which impedes progress in effective cash management. The Treasury Department has instructed Federal agencies to adopt formal practices designed to preclude unnecessary borrowing. Some early payments result from a desire to maintain good relations with contractors. Some agencies are hopeful for lower prices and want to encourage more contractors to do business with the Government. Another reason for paying before the due date might be the goal of paying "as soon as possible."[5]

Discount for Early Payment

Payment prior to the due date, however, sometimes is a desirable goal. Contractors sometimes offer a discount for early payment. In order to determine whether to accept the discount offered for early payment, the Treasury Fiscal Requirements Manual mandates use of the following formula:[6]

$$\frac{\text{DISC \%}}{\text{100\% - DISC \%}} \times \frac{\text{DAYS IN YR}}{\text{PAY PRD DAYS - DISC DAYS}}$$

$$= \text{EFFECTIVE ANNUAL DISCOUNT RATE}$$

IF EFFECTIVE ANNUAL DISCOUNT RATE EXCEEDS CURRENT VALUE OF FUNDS RATE - ACCEPT DISCOUNT.

IF EFFECTIVE ANNUAL DISCOUNT RATE IS LESS THAN CURRENT VALUE OF FUNDS RATE - REJECT DISCOUNT.

If the effective annual discount rate exceeds the current value of funds rate (published semi-annually by the Treasury Department), the discount is accepted. If the reverse is true, the discount is rejected. Quite simply, if the benefit to the Government of paying early exceeds the cost of borrowing the funds, the discount is taken and payment is made within the specified time period. If it is determined that the discount will be accepted, the invoice should be paid in a timely fashion, within the discount period for the offer. According to FAR 52.232-8, Discount for Prompt Payment, the clock begins when delivery has occurred or when a proper invoice has been received in the specified Government office, whichever is later, in computing the due date for payment if a discount is to be taken. Per FAR 14.407-3, an offer of a discount for early payment may not be included in the evaluation of a bid.

Reference was made earlier to some studies by the GAO and to Congressional hearings to determine the extent of the problem in the Government's bill-paying process. These proceedings led to passage of Public Law 97-177, commonly known as the Prompt Payment Act, in May 1982.

Features of Prompt Payment Act

The Prompt Payment Act required that the Office of Management and Budget (OMB) issue implementing instructions, which it did through OMB Circular A-125 in August 1982. In turn, each executive agency was required to issue internal implementing instructions by 1 October 1982.

So it is apparent that Prompt Payment is an issue that has been publicly debated for quite some time. And various responsibilities, suggested actions, permitted actions, and forbidden actions are delineated in the U.S. Code, public law (Prompt Payment Act and Prompt Payment Act Amendment of 1988), OMB instructions, and the FAR and DoD FAR Supplement.

This paper will provide highlights of several of the features of the Prompt Payment Act and associated regulations: FAST PAY, penalties for late payment, and electronic payment.

FAST PAY

The FAST PAY process is explained in Section 13.3 of the FAR. It is a program designed to improve supplier relations by expediting payment for small purchases. Actually, this feature was added to the Armed Services Procurement Regulation (ASPR) in 1965, so it has been in force for a considerable period of time. It is applicable for orders not exceeding $25K where the Government takes title when the item is delivered to the Post Office or carrier and where the supplier agrees to replace, repair, or correct supplies not received at the destination, damaged in transit, or not conforming to the purchase requirements. Payment is based upon the contractor's submission of an invoice certifying that delivery has been made to the Post Office or carrier and that the contractor agrees to take corrective action if necessary. However, if corrective action is necessary, that notification must be made to the contractor within 180 days of the time that title passes to the Government. The payment office is authorized, then, to make payment without a receiving report or evidence of acceptance.

Use of the FAST PAY provisions authorized by the FAR would be particularly beneficial in transactions of a repetitive nature. In a study of payments to contractors, the GAO found that recurring payments were nearly twice as likely to be paid late as those involving occasional or one-time procurements. [7] Transactions of a recurring nature give the applicable agency leverage over a contractor in the area of corrective action.

However, as the GAO has pointed out in its Report to the Congress entitled, Controls Over Expedited Payments to Defense Suppliers Need Improvement, agencies must exercise caution with FAST PAY. Only those transactions which total $25K or less should be handled in this way. Also, vendors who are slow or reluctant to take corrective action on items not conforming to specifications should be denied FAST PAY privileges. FAST PAY is intended to serve both the Government and industry. However, each party must honor its responsibilities.

Certificate of Conformance

A Certificate of Conformance (CoC) is another vehicle which allows the contractor, when authorized by the Contracting Officer, to ship and receive payment for supplies which would require inspection at the source. The Government may reject defective items within a reasonable period after delivery by written notification to the contractor. The contractor may be paid on the basis of its certification. The CoC clause, as found in FAR 52.246-15, is as follows:

"I certify that on ..... (insert date), the .... (insert contractor's name) furnished the supplies or services called for by Contract No......via......(Carrier) on ......(identify the bill of lading or shipping document) in accordance with all applicable requirements. I further certify that the supplies or services are of the quality specified and conform in all aspects with the contract requirements, including specifications, drawings, preservation, packaging, packing, marking requirements, and physical item identification (part number), and are in the quantity shown on this or on the attached acceptance document."

Date of Execution..............
....
Signature......................
....
Title..........................
....

Penalties for Late Payment

Within 60 days after the end of each fiscal year, each executive agency is required to submit to the Director, OMB, a report providing details on any interest penalties incurred during the fiscal year. Agencies are supposed to cite the appropriate reason(s), from the list proposed by OMB. Those reasons are as follows:

1. Contract not available in payment office
2. Delay in receiving

documentation

3. Delay in certification of invoice
4. Delay in payment office
5. Military exercise in progress
6. Discount taken in error
7. Vendor not notified of defective invoice in sufficient time
8. Automated system processing delay
9. Delay caused by U.S. Postal Service
10. Other

It is important to remember that Congress imposed penalties for late payment, whether or not the vendor is aware of his rights and/or seeks to enforce them. If a payment is due and is not made, a penalty is owed.

The discussion up until now has revolved around contracts where all items are delivered at one time and payment follows. These are relatively short-term contracts. Payment may be made in installments if delivery is made in that fashion. There are several methods by which a contractor may receive funds for longer-term efforts. Part 32 of the FAR distinguishes between payments which are made on the basis of "progress" and "advance" payments. Advance payments are made to ensure that work is carried out on a contract in a timely fashion. Sometimes they are utilized to place an under-capitalized firm on equal footing with a firm that has a greater supply of capital. This is due to the fact that start-up costs are often tremendous. Advance payments are expected to be liquidated from payments due to the contractor for performance of the contract. Government financing should only be used to the extent actually needed for prompt and efficient performance, considering the availability of private financing. Progress payments may be made to the contractor on the basis of costs incurred as work is performed. Payments may be made for partial deliveries accepted by the Government. A contractor may be compensated for work that is of a research and development nature, as opposed to having a deliverable product, by submitting invoices as costs are incurred.

Electronic Payment

The Prompt Payment Act and other documentation addresses electronic payment. In the mid-1980s the Federal Government began a program to pay some of its bills electronically. By August 1987, approximately 45 percent of the federal salary and benefits payments, about 260 million transactions per year, were directly deposited in bank accounts.

Recommendations

Although the Federal Government has an acceptable record, in general, concerning its dealings with vendors, there is always room for improvement. Decentralizing the payment function would allow organizations placing orders to make payment for those orders. The two functions could be carried out within the same organization but would not be carried out by the same individual(s). The threshold of $25K comes to mind as appropriate for this avenue since that is the dollar level threshold for transactions eligible for FAST PAY.

Use of the FAST PAY practice would enable the Government to realize cost savings which would be particularly helpful with today's tight resources. FAST PAY would allow us to take advantage of virtually every discount for early payment that is offered and is considered to be worthwhile.

Electronic payment is another practice that would allow agencies to wait until the last possible moment to make payment without being considered late. Some companies even offer a discount for electronic payment.[9] One definite advantage is that payment is considered to be complete when the transfer goes through.

In lieu of a definite payment schedule in the contract, 30 days from delivery is considered to be the norm. In order for the relationship between the vendor and the Government to be as straight-forward as is possible, payment terms should be explicitly stated, with consideration paid to the nature of the item as far as determining as reasonable period of time for acceptance.

Conclusion

In conclusion, the Federal Government should carefully evaluate the discounts it is offered for early payment and for the ones it accepts - pay within the stipulated period. The payment function for commercial "off-the-shelf" items costing $25K or less should be decentralized. FAST PAY should be utilized wherever possible. Electronic payment to vendors should be pursued wherever practicable. Also, clear payment terms should be included in the contractual document.

Adherence to these guidelines should help a great deal in furthering the relationship between the business community and the Government.

Endnotes

[1] Elmer B. Staats, "The Federal Government's Bill Payment Performance Is Good But Should Be Better," Report to the Congress by the Comptroller General of the United States, 24 February 1978, p.5.

[2] Arthur W. Landrigan, Jr., "Prompt Payment - A Costly Myth," Armed Forces Comptroller, Spring 1987, p. 26.

[3] OMB Circular No. A-125, Revised 9 June 1987.

[4] Staats, p. 25.

[5] Staats, p. 27.

[6] "Disbursements for Goods and Services," Treasury Fiscal Requirements Manual for Guidance of Departments and Agencies, Part 6, Section 8040.

[7] Staats, p. 14.

[8] Robert Guenther, "U.S. Treasury Pays Suppliers Electronically," The Wall Street Journal, 24 August 1987, p. 25.

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